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The association between the social and communication impairments and repetitive/restricted interests and behaviours of ASD in a clinical sample: Does the triad still fit?

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V. ABSTRACT

Introduction: Autism Spectrum Disorder (ASD) is a behaviourally defined disorder characterised by impairments in three domains of social interaction, communication, and repetitive/restricted interests and behaviours (DSM-IV-TR; APA, 2000; ICD-10; WHO, 1992). Recent research suggests that this diagnostic triad may no longer fit as the best way to conceptualise ASD. Although not due for publication until 2013, a proposed revision of autistic disorder for DSM-V has merged three domains into two; i) Social/communication deficits and ii) Fixated interests and repetitive behaviours (APA, 2010). The aim of this study was to examine the structure of ASD symptom domains within the Adult Asperger Assessment (AAA; Baron-Cohen *et al.*, 2005).

Method: Confirmatory factor analysis was used to examine data from a clinical population of adults diagnosed with Asperger Syndrome (AS) and High Functioning Autism (HFA).

Results: Analysis suggested that none of the theoretically-driven models were supported by the AAA data. However, it did highlight high correlations between social and communication factors ($r > 0.9$) within unmodified models.

Discussion: The results of the analysis did not provide support for the move towards considering ASD as a dyad of 'social-communication' impairments and repetitive/restricted interests and behaviours, as none of the models were supported by the AAA data The validity of the AAA as a diagnostic tool is discussed, as well as limitations and suggestions for future research.

Conclusion: This study did not provide the evidence required to endorse a move towards the proposed DSM-V dyad. Further research to understanding the structure of autism symptoms could improve diagnostic and classification systems, and further studies of the genetic and neurobiological bases of ASD.

1 INTRODUCTION

1.1 Chapter Summary

The introductory chapter begins with a systematic review of the literature. Following the copy of the systematic review are aims and hypotheses. An Introduction 'Bridge' is also included in this chapter to give some background to the assessment used for analysis, and a note on terminology.

1.2 Systematic review

A version of this review was accepted for publication by the journal *Research in Developmental Disabilities* (Kuenssberg, McKenzie & Jones, 2011). The guidelines for authors from this journal can be found in Appendix 1. As dictated within these guidelines, the systematic review follows APA guidelines. Please note the main body of the thesis follows BPS style guidelines.

The association between the social and communication elements of autism, and repetitive/restrictive behaviours and activities: A review of the literature.

Abstract

Research continues to try and pinpoint the etiological role of particular genes and brain structure in autistic spectrum disorder (ASD), but despite a host of biological, genetic and neuropsychological research, the symptom profile of Pervasive Developmental Disorders (PDD) are not yet linked to etiological theory. Debate continues around whether or not there is one single dimension that incorporates the three criteria domains of social difficulties, communication deficits and repetitive or restrictive interests and behaviours as a unitary 'ASD' concept, or whether PDD as they are currently described represent the co-occurrence of separate sub-domains of developmental difficulties. Although the three criteria need to be met for a diagnosis of PDD to be made, the association between them remains unclear. This review highlights that the majority of the literature that looks at the triad of impairments suggests the symptom structure does not match that proposed by diagnostic manuals, and that the triad may no longer fit as the best way to conceptualise ASD.

1. Introduction

Autism was first officially described in the Diagnostic and Statistical Manual of Mental Disorders - 3rd Edition (DSM-III; American Psychiatric Association [APA], 1980). Before this, controversy surrounded the validity of autism spectrum disorder (ASD) as a diagnostic concept, with debate as to whether or not it was best conceptualised as the earliest onset of schizophrenia (Volkmar, Bregman, Cohen, & Cicchetti, 1988). In DSM-III, infantile autism was included in the new diagnostic class of Pervasive Developmental Disorder (PDD). Diagnostic criteria for this class of disorder were based on Kanner's original description of two core features of infantile autism ('extreme aloneness' and 'preoccupation with the preservation of sameness'; Kanner, 1943) and Rutter's subsequent reappraisal of a triad of impairments (Rutter, 1968). A child had to exhibit an early disturbance with onset before 30 months, characterised by a pervasive lack of social relationships and deficits in language and/or communication, with an absence of delusions and hallucinations as found in schizophrenia (APA, 1980).

DSM-III criteria for PDD were revised for the DSM-III-R (APA, 1987). It was felt the criteria needed a more developmental focus to reflect that individuals did not stop exhibiting the disorder after early childhood, but continued experiencing difficulties throughout development (Volkmar et al., 1988). Three overarching categories described the criteria that had to be met for a diagnosis in the DSM-III-R: social dysfunction; qualitative impairments in verbal and nonverbal communication and imaginative activity, and; a restricted range of activities or interests (APA,

1987). Today, PDD continue to be characterized in DSM-IV-TR (APA, 2000) and the 10th edition of the International Classification of Diseases and Related Health Problems (ICD-10; World Health Organisation [WHO], 1992) by impairments in the three domains of social interaction, communication, and repetitive, stereotyped behaviours and activities. Although not due for publication until 2013, a proposed revision of autistic disorder for DSM-V (APA, 1994) has merged three domains into two: social/communication deficits and fixated interests and repetitive behaviours (APA, 2010).

As such, autism is still a behaviourally defined disorder. Research continues to try and pinpoint the etiological role of particular genes and brain structure, but it is not yet linked to the symptom profile of PDD (Mandy & Skuse, 2008). Autism was traditionally conceptualised as a discrete category, qualitatively different from other presentations, but a consensus is emerging that autism is in fact a dimensional disorder reflecting difficulties at the extreme end of a continuum (Mandy & Skuse, 2008). However, debate continues around whether or not there is one single dimension that incorporates the three domains of social difficulties, communication deficits and repetitive or restrictive interests and behaviours as a unitary 'ASD' concept, or whether PDDs as they are currently described represent the co-occurrence of separate sub-domains of developmental difficulties. Although the three criteria need to be met for a diagnosis of PDD to be made, the association between them remains unclear.

Delineating the construct of autism into more than a single 'ASD' dimension could further studies of the genetic & neurobiological bases of PDD (Cuccaro et al.,

2003). One method authors have used to explore the structure of autism is by using factor analysis. Factor analytic techniques are used to pull out underlying structures (known as factors or components) by identifying which items co-vary (Kline, 1994). As such, factor analysis can examine whether or not the social, communication and repetitive interests/behaviour domains of autism co-vary. If they do, they should not show up as separate factors. However, although factor analysis can test the fit of the three factor hypothesis, some difficulties do exist. Results can be profoundly influenced by sample characteristics, size and the type of measure used, and bias can be introduced in the interpretation and the naming of particular factors (Field, 2005).

The aim of this systematic review was to identify papers that explored the structure of autism to see if this research can clarify the association between the social deficits, communication impairments, and repetitive/restrictive behaviours and activities found in autism and PDD: Does the triad of impairment still fit?

2. Method

2.1 Search Strategy

Key words were gathered from previous literature searches. The search terms autis* OR asperger* OR pervasive developmental disorder were combined with AND struct* and used to search Ovid databases. These were Medline (1950-May wk 1 2010), Embase (1980- wk 18 2010), Psych info (1967–May wk 2 2010), EBM Review Cochrane Database of systematic reviews (2005-March 2010), EBM Review Cochrane methodology register (2nd Quarter 2010), British Nursing Index and

Archive (1985-2010). This range of databases was chosen as they cover social science and psychological research, to try to minimise database bias. The start of the search was chosen by the earliest year available on each database, in order to try to capture any possible relevant discussion pre-DSM-III (APA, 1980), when autism was first diagnostically described.

2.2 Inclusion and exclusion criteria

The systematic review looked to identify papers that used DSM-IV-TR stipulated symptom dimensions (qualitative impairment in social interaction, qualitative impairments in communication, and repetitive or restricted interests, behaviours and activities [RIBA]). Articles using tools that had different symptoms to those proposed by the DSM triad (e.g., arousal, affect and cognition: Eaves & Williams, 2006; social skill, communication, imagination, attention to detail and attention switching: Hoekstra, Bartels, Cath, & Boomsma, 2008) or that only contained two of domains of (e.g., only social and communication domains; Magyar & Pandolfi, 2007) were excluded. Thus, papers were excluded if they solely focused on one diagnostic criterion such as communication disorders, empathy/social cognition, or repetitive interests/behaviours or activities, rather than the triad of impairments. Similarly, studies that did not examine the diagnostic triad but focused on secondary difficulties such as challenging behaviour or specific language disorders were excluded. Studies that examined brain structure with no reference to the triad of impairments in terms of symptoms were excluded. Only papers written in

English were included and two papers needed to be excluded due to sourcing difficulties (Foster, 2003; Tien, 2008; both dissertation abstracts only).

2.3 Quality Indicators

Each study was considered by using quality indicators self-devised but guided by national recommendations (National Institute for Health and Clinical Excellence [NICE], 2009; Scottish Intercollegiate Guidelines Network [SIGN], 2008). Each paper was reviewed against five quality criteria; clarity of research question (based on SIGN recommendations: well addressed, adequately addressed, poorly addressed, not addressed/not reported), study design (adequate sample size, sample diagnoses, method of diagnosis, measure used), type of analysis (particular weight was given to studies that used confirmatory analysis and referred to existing theory or findings), and interpretation of results (again based on SIGN recommendations). This then led to an overall assessment of the study (OA) being coded, based on how well the study was conducted according to the criteria (++, + or -). The OA valued high quality methodology most, as factors such as sample characteristics, sample size, and type of measure will have a profound effect on the results obtained by factor analysis (Kline, 1994).

2.4 Results

This search strategy yielded 3,922 potentially relevant citations, which was reduced to 2,538 after extraction for duplicates. All titles were examined and

considered using the search criteria described above. In total 244 relevant articles were identified by title, and abstracts selected. From abstract selection, 44 studies were identified as being eligible, and full papers were sourced to confirm relevance. These papers were then examined, and 14 full papers remained.

2.5 Characteristics

The 14 papers reviewed (see table 1) look to clarify the autism construct by examining the relationship found between each diagnostic criteria of the triad and the association between domains. Sample size and demographic information is highlighted, along with the diagnostic tool, and how many factors each research group identified. The overall assessment of the study (OA) based on the quality indicators is also displayed.

Table 1: Summary of reviewed papers

Author	Sample size	Diagnosis	Age (years)	Diagnostic Instrument analysed	Statistical technique used	Number of factors	OA
Wadden, Bryson & Rodger, 1991	123	Autism or ID[1]	6-15	ABC[2], mental age and chronological age	EFA[20]	Three factors: 1.Non-responsive 2.Aloof/Repetitive 3.Infantile/Aggressive	–
Soucy & Andrews 1997	24	PDD	2-7	BSID-II[3], AVC[4], PEP-R[5], E2[6], PSBC[7], CARS[8], RCA[9], ECA[10], VABS[11]	PCA[21]	Four factors 1.Social Cognition 2.Langauge 3.Deviant Behaviour 4.Developmental	–
Szatmari et al. 2002	129	PDD	4-17	ADI[12] & VABS	PCA	Two factors: 1.Autistic symptoms 2.Level of functioning	+

Tadevosyan-Leyfer et al. 2003	292	Autism	2-47	ADI & ADI-R[13](common items)	PCA	Six factors: 1.Spoken language 2.Social intent 3.Compulsions 4.Developmental milestones 5.Savant skills 6.Sensory aversions	+
Constantino et al. 2004	226	PDD & unspecified developmental disorder (no ID)	4-18	ADI-R (all 12 subdomain scores) SRS[14]	Cluster analysis & PCA	Single underlying 'autism' factor	+
Lecavalier et al. 2006	226	PDD or ADHD	5-11	ADI-R (algorithm)	EFA & CFA[22]	Three factors: 1.Social 2.Communication 3.Repetitive Behaviour	++
van Lang et al. 2006	255	PDD & typically developing	4-20	ADI-R (algorithm)	CFA	Three factors: 1.Impaired social communication 2.Impaired make believe and play 3.Stereotyped language and behaviour	++
Georgiades et al. 2007	209	PDD	2-40	ADI-R (all subdomain scores)	PCA & CFA	Three factors: 1.Social-Communication 2.Inflexible Language and Behaviour 3.Repetitive sensory and motor behaviour	++

Posserud et al. 2008	6229	General population only	7-9	ASSQ[15]	EFA	Three factors: 1.Social function 2.Autism-associated problems 3.Cognitive style associated with HFA/AS	–
Frazier et al. 2008	1170	Autism	2-46	ADI-R (algorithm)	PCA & CFA	Two factors: 1.Stereotyped language & RIBA 2.Impairments in social interaction & communication	++
Dworzynski et al. 2009	189	PDD	10-12	DAWBA[16]	EFA	Five factors: 1.Social Behaviours 2.Communication 3.Language delay 4.RIBAs (repetitive) 5.RIBAs (insistence of sameness)	+
Lecavalier et al. 2009	730	PDD	3-12	ECI-4[17] & CSI-4[18]	CFA	Three factors: 1.Social 2.Communication 3.Repetitive Restricted Behaviours	++
Snow et al. 2009	1861	PDD	4-18	ADI-R (algorithms only)	EFA & CFA	Two factors: 1.Social/communication items 2.Restricted/repetitive behaviour items	++

Kamp-Becker et al. 2009	140	PDD & typically developing	6-24	ADI-R (items) ADOS-G[19] (module 3 and 4)	EFA	ADI-R 4 factors: 1.Social Communication 2.Anxiety and Compulsions 3.Stereotyped Behaviour (verbal and nonverbal) 4.Inadequate Behaviours ADOS-G 5 factors 1.Social communication 2.Non/Verbal Behaviour 3.Hyperactivity 4.Stereotyped Behaviour 5.Interests and Compulsions	+

Note: [1]Intellectual Disability, [2]Autism Behaviour Checklist, [3]Bayley Scale of Infant development- Revised, [4]Auditory-Visual Combined Discrimination test, [5]Psyhcoeducational Profile-Revised, [6]Diagnostic Checklist for Disturbed Children, [7]Preschool Social Behaviour Checklist, [8]Childhood Autism Rating Scale, [9]Receptive Communication Age Score, [10]Exprtessive Communication Age Score, [11]Vineland Adaptive Behaviour Scale, [12]Autism Diagnostic Interview (and [13]Revised), [14]Social Responsiveness Scale, [15]Autism Spectrum Screening Questionnaire, [16]Development and Wellbeing Assessment, [17]Early Childhood Inventory-4, [18]Child Symptom Inventory-4, [19]Austism Diagnostic Observation Schedule (Generic), [20]Exploratory Factor Analysis, [21]Principal Components Analysis, [22]Confirmatory Factor Analysis

3. Review of the literature

3.1 ASD as a single dimension

The review identified one paper that identified autism as a single dimension, and a second paper that collapsed the three domains into a single 'autism symptom' scale. As can be seen in the table 1, both these papers received an OA of '+'. Constantino et al. (2004) examined the factor structure of autistic traits by cluster analysis of 'present/absent' data from all the items of the *Autism Diagnostic Interview-Revised (ADI-R*; Lord, Rutter, & Le Couteur, 1994) and principal components factor of data from the *Social Responsiveness Scale*, a third-party completed rating scale (*SRS*; Constantino, 2002). The authors explored whether the three domains of difficulties could be separated within an established clinical sample. Analysis of the *SRS* dataset revealed the presence of a primary factor that explained more than 30% of the phenotypic variance. The next three most influential factors each explained less than 7% of the variance. When the primary factor was examined, items represented all three of the DSM-IV-TR criteria of language deficits, social deficits and restricted interests or odd repetitive behaviours.

Cluster analysis of the *ADI-R* dataset yielded similar results. The authors' analysis supported a ten factor solution, in which the first two factors were made up of almost half of the 63 *ADI-R* items, and accounted for 27% of variation in the data. The first cluster was characterised by questions relating to social deficits, nonverbal and verbal communication deficits and sensitivity to noise. The second cluster was characterised by symptoms across all three DSM-IV-TR criteria domains, including difficulties with group play, reciprocal conversation and echolalia, and repetitive or

stereotypic behaviours. However, a strong correlation between these neighbouring clusters suggested significant overlap between the two. The *ADI-R* data was then subjected to principal components analysis, in which a primary factor was found to account for 40% of the variance. This factor included items from all three criteria domains for PDD. Constantino et al. (2004) concluded that their data supported the presence of a single underlying variable of autistic spectrum conditions, manifesting characteristics across the three domains. They did not find evidence of independent sub-domains of deficits in social skills, language or repetitive/restrictive activities and behaviours.

Constantino and colleagues used exploratory methods due to sample size limitations. Although helpful in exploring data, it is not optimal in testing hypotheses or answering questions on structure, the area of interest for the current review, when theories already exist (Field, 2005). Furthermore, each sample was small for the number of items within the assessment tool, and the sample had a mix of diagnoses and symptom severity. Although the authors argue that the inclusion of individuals with a wide range of autistic symptomatology is important to avoid amplification of a specific structure within a narrow range of severity (for instance, a structure that may only exist at the extreme end), they acknowledge that their sample was not large enough to reliably fit the goodness of fit of their single factor model. However, they did not report whether there was a difference in structure between groups before combining their sample. Another note of caution is that the *SRS* is heavily orientated towards social language, which could have given extra weight to the single factor

finding, although this would not explain their finding using the *ADI-R*, a tool that, as the authors report, is recognised as a 'gold-standard' parental report.

Szatmari et al. (2002) also examined whether PDDs are composed of distinct dimensions of autistic symptoms or a single 'autism' construct, but they included level of functioning as a possible dimension that could account for the varying symptoms or phenotypic variation observed within PDDs. They used exploratory techniques on data from the *ADI* (1989 version: LeCouteur, Rutter, Lord, & Rios, 1989) and the *Vineland Adaptive Behaviour Scales (VABS*: Sparrow, Ball, & Cicchetti, 1984). Their sample was made up of two groups, one 'lower functioning', as measured by the *VABS* with a diagnosis of autism, and one who met their criteria for high functioning autism (HFA) or Asperger Syndrome (AS). Of note however, is that the authors decided not to use IQ as a measure of level of functioning, but relied on the *VABS* score. Measurement of IQ could have been used as an additional measure of the validity of each 'level of functioning' subgroup, and the authors note that they did not use a representative sample of children with ASD. Diagnosis of ASD was made by a best-estimate diagnostic procedure based on DSM-III-R criteria, using the opinions of two psychiatrists, before the *ADI* was completed. If no discrepancy between reports were noted, they joined the sample. As there was no algorithm from the *ADI* for AS, the authors derived their own on the basis of previous work (details of their diagnostic process can be reviewed in Szatmari et al., 2000).

Principal components analysis was performed on the *ADI* and *VABS* ratings within each group. The authors also analysed the pooled sample after checking that

the factor structure was stable across both groups. This is important because as described, characteristics of the sample can profoundly influence the results of factor analysis. As both groups showed similar factor structure, they were able to be combined to provide more precise estimates of factor loadings. Two factors were identified that explained almost 70% of the variance. Factor 1 represented 'level of functioning,' being made up of the scores on the *VABS*, whereas factor 2 comprised of 'the autism symptom factor', the scores from the *ADI*.

Again, Szatmari et al. (2002) only used exploratory techniques despite a previously proposed theoretical structure being reported. Confirmatory factor analysis may have been more appropriate, as PCA is inductive and hypothesis generating. The authors acknowledge that their population was not a representative sample of children with PDD, however, they concluded their results were indicative of two dimensions underlying the phenotypic variation in autism; a symptom domain and a level of functioning domain. They conclude that the three domains should be collapsed into one single scale of 'autism symptom', but that a single dimension that focuses on ASD is perhaps an oversimplification.

3.2 Separate sub domains corresponding to DSM-IV-TR criteria

Other studies reviewed suggest there is not a single 'autism' construct, but that PDDs are made up of at least three separate sub domains of difficulty that correspond directly to DSM-IV-TR criteria; social deficits, communication deficits and repetitive/restrictive behaviours and activities. Lecavalier and colleagues

(Lecavalier, Gadow, DeVincent, Houts, & Edwards, 2009) investigated the structure of PDD symptoms by using a well designed study and confirmatory factor analysis, which scored an OA of '++'. They used a large sample of consecutive child referrals with a full range of symptom severity, diagnosed using DSM-IV criteria. Diagnosis was made following parent interview and observation of the child, comprehensive developmental history and educational evaluation, and both parents and teachers completed the *Early Childhood Inventory (ECI-4*: Gadow & Sprafkin, 2000) and the *Child Symptom Inventory-4 (CSI-4*: Gadow & Sprafkin, 2002). These are DSM-IV referenced rating scales with good psychometric properties.

Analyses focused on the entire sample and separate subgroups divided by age, diagnosis and cognitive ability. The authors tested a one factor model, a two factor model of social-communication items as one item and repetitive/restricted behaviours as the other, and a three factor model corresponding to the DSM-IV triad of impairments. Their results clearly favoured the three factor solution for both teacher and parent data, with the one and two factor models yielding poor fits for both groups of informant regardless of subject characteristics.

Dworzynski, Happe, Bolton and Ronald (2009) used exploratory factor analysis on data from the *Developmental and Wellbeing Assessment (DAWBA*; Goodman, Ford, Richards, Gatward, & Meltzer, 2000) to explore the factor structure and relationships between core features of autism. The *DAWBA* is an interview package used to generate DSM-IV and ICD-10 diagnoses, administered by trained lay interviewers over the telephone. It is not ASD specific but is used by the Office of National Statistics, so only questions relating to ASD were administered. This

diagnostic procedure does not correspond to best practice (e.g., SIGN, 2007). This design, along with a limited sample size, resulted in an OA rating of '+'. Exploratory factor analysis identified five factors which accounted for just over 45% of all variance. Factor one (accounting for the majority of the variance at just over 16%) was concerned with social behaviours and impaired play, with communication difficulties accounted for by factor two, and language milestones factor four. Factors three and five were similar, both covering repetitive/restrictive interests and behaviours, but with the emphasis on 'repetitiveness' and 'insistence on sameness' respectively. Thus, this data recognised the triad described by DSM-IV criteria, but split both communication difficulties and repetitive interests/behaviours and activities into two further factors. The sample was not large enough to determine whether or not the authors' solution was a better fit than that described by Lecavalier and colleagues (2009).

3.3 Separate sub domains not described by DSM-IV-TR criteria

Symptom domains were examined by van Lang et al. (2006) who used data from the *ADI-R* algorithm to explore the structure of autism in a well-designed study using both exploratory and confirmatory methodology (OA of '++'). They tested the goodness-of-fit of five different models against data from *ADI-R* subscale scores. The first and second model corresponded to the DSM-IV-TR triad, with the first applying to participants' behaviour at age 4-5 years, and the second to current behaviour. Their third factor model was hypothesised from the authors' explorative findings with three factors; impaired social communication, stereotyped language

and behaviours, and impaired make-believe and play skills. The fourth model was constructed as a single 'autistic features' symptom domain, and the fifth a two factor model consisting of 'impaired social communication' and 'stereotyped language and behaviours'.

Within confirmatory factor analysis, a robust Maximum Likelihood (ML) estimation procedure was used to offset the non-normal distribution of the data, examining the goodness-of-fit of each of their suggested models. Both the DSM based models encountered difficulties as the domain of impaired social interaction and domain of impaired communication were highly correlated, and so could not be properly estimated (van Lang et al., 2006). The authors' third own-hypothesised three factor model fitted the data better than any of the others, although this still only explained 34% of the variance. Although this model was based on the symptomatology of autism, it had a different structure than that of the DSM-IV-TR triad. Instead, 'impaired social communication' accounted for information about difficulties in both verbal and nonverbal social communication, 'impaired make-believe and play' described the fundamental lack of play skills in play with peers and self, and 'stereotyped language and behaviour', described restrictive characteristics in speech and behaviour. Thus, the model supported by their data did not fit the traditional triad.

The hypothesised model described by van Lang and colleagues (2006) had been constructed from two exploratory studies that were included in the sample, so an independent cross-validation is required. In addition, although their model was stable for the sample with intellectual disability, it is unknown if it would continue to

be stable in higher functioning individuals. Overall, however, this was a well designed study that led the authors to conclude that their model offers a better representation of the symptom structure of autism than the DSM-IV-TR triad.

Other authors' research also led them to conclude that the triad is not the 'best fit'. Tadevosyan-Leyfer et al. (2003) performed exploratory principal components analysis in order to attempt to break down the autism phenotype into genetically relevant components. Common items from the *ADI* and *ADI-R* were used, rather than just the algorithm items. The group identified a model with 6 factors that accounted for 41% of the variance, and validated their model with a small independent sample. One of the factors they identified, 'social intent', is very similar to the 'impaired social communication' factor identified by van Lang et al. (2006), but the models differed regarding stereotyped language and behaviours. The authors concluded that their results supported a move to return to two diagnostic criteria as originally proposed by Kanner in 1943, focussing on the social deficits and the 'insistence of sameness'. They concluded the two current standard criteria for autism, communication and social interaction, are not independent.

Georgiades and colleagues (2007) also used data from the *ADI-R* algorithm to search for the underlying structure of the autism phenotype. They used principal components analysis, followed by confirmatory factor analysis, in a well designed study which received an OA rating of '++'. They had a good sample size, with all participants having been diagnosed with a range of PDDs. Results suggested that a three factor solution was the best fit, accounting for 50% of the variance. The authors described these three factors as 'social-communication', 'inflexible language and

behaviour', and 'repetitive sensory and motor behaviour'. The combined social communication factor covers both domains as described in the DSM-IV and lack of varied spontaneous social or make-believe play. The repetitive/restrictive domain is split over two factors, one covering stereotyped language and preoccupation with patterns of interest, and the other including sub-domains that measure stereotyped motor mannerisms and preoccupation with sensory stimuli and objects. They conclude that the autism symptom phenotype is made up of three domains that are different to those described by the DSM-IV, and are certainly not composed of a single autism domain.

Not all studies that proposed a diagnostic structure different to the DSM were as well designed. Three studies which proposed a different structure to DSM but scored an OA of '-' were Wadden, Bryson, and Rodger (1991), Posserud et al., (2008) and Soucy and Anrews (1997). Wadden, Bryson and Rodger (1991) performed an exploratory factor analysis on the *Autism Behaviour Checklist (ABC;* Krug, Arick, & Almond, 1980a, 1980b) to explore the structure of this diagnostic instrument and its diagnostic discriminant ability. They had a very small sample, and did not report gold standard diagnostic procedures. However, their research question related to the psychometric qualities of the ABC tool, rather than the structure of autism. They concluded the *ABC* taps into three different aspects of autistic behaviour: 'nonresponsive' (an underlying failure to respond to the environment and social inattentiveness); 'aloof/repetitive' (both verbal and motor repetitiveness, poor eye contact) and; 'infantile/aggressive' (temper tantrums, aggression, communicating by gestures). Although they were not addressing the structure of autism per se, within

their data they found no evidence for a single autism factor, and their model did not fit the traditional triad.

Similarly, Posserud et al. (2008) investigated the factor structure of the *Autism Spectrum Screening Questionnaire (ASSQ*: Ehlers & Gilberg, 1993). The aim of their study was to clarify how to separate ASD from cases of social impairment due to other causes, using a very large sample from the general population. The *ASSQ* is a teacher and parent self-report questionnaire covering social interaction, verbal and nonverbal communication and restricted/repetitive behaviours and motor clumsiness. Exploratory factor analysis supported a three factor solution for both respondent groups. The first factor was labelled 'social difficulties', the second 'tics/motor/OCD' as it included many items relating to repetitive, stereotypic behaviour in autism. The third factor was labelled 'autistic style' denoting the cognitive style and language characteristics seen in high-functioning individuals with autism. They concluded it was this third factor that was key in identifying the qualitative difference in difficulties between autism and other causes of social impairment. Posserud et al. (2008), however, stress that their data were not intended to be interpreted as an analysis of dimensions within autism, as their sample was not a PDD clinical population, but was obtained from the general population. This sample was chosen as the *ASSQ* was originally developed as a screening measure to identify children who may need further clinical assessment, rather than as an instrument to confirm a diagnosis of ASD.

Soucy and Andrews (1997) attempted to explore the underlying structure of autism by looking to try and subtype children with a diagnosis into distinct groups.

They used a large battery of assessments and exploratory factor analysis, and reported finding four factors that did not correspond to DSM criteria. However, their very small sample of only 24 children limits the value of their findings.

3.4 Merging of DSM-IV-TR criteria

Although some studies have suggested that social and communication difficulties are separate domains, other research suggests that they load onto one single factor. Lecavalier et al. (2006) examined the algorithm items of the *ADI-R* to assess its validity within a study that earned an OA rating of '++'. Exploratory and confirmatory factor analysis found a three factor model fit the data best, explaining 38% of the variance. However, they did use the same sample to compare the results of the exploratory functional analysis with the *ADI* algorithm modelled on DSM-IV-TR criteria, despite the identified risk of capitalising on chance. While their model closely resembled the DSM-IV-TR diagnostic symptom domains, there was one discrepancy, in that all nonverbal communication items were associated with the social factor. This factor accounted for just over 21% of the variance. 'Communication' needed to be split between nonverbal and verbal skills, as social deficits and communication deficits did not appear to be distinct. Although Lecavalier and colleagues (2006) were assessing the validity of the *ADI-R*, they report that their psychometric results can add to the debate about the behavioural dimensions of the autistic phenotype, in that their study highlights the overlapping nature of symptoms regarded as separate domains.

Frazier, Youngstrom, Kubu, Sinclair, and Rezai (2008) also examined the factor structure of the *ADI-R* algorithm using both exploratory and confirmatory factor analysis methods (OA ++), and used a much larger sample than that of Lecavalier and colleagues (2006) sourced from a longitudinal dataset. They also examined the factor structure across two age groups. Again, their data indicated that the factor structure of the *ADI-R* used to diagnose autism is different to that described by the DSM-IV-TR triad. Instead, a two factor structure was presented, with restricted/repetitive and stereotyped behaviour loaded with stereotyped language onto one factor, and impairments in social interaction and communication combined together on a second factor. The authors suggest autism domains may need to be restructured to more accurately reflect the strong relationship between social and communication impairments, and to separate them from stereotyped and repetitive behaviours.

Snow, Lecavalier, and Houts (2009) investigated the factor structure of the *ADI-R* by using every item rather than the algorithm, but used the same longitudinal dataset as Frazier et al. (2008) as part of their large sample. Their methodology also earned an OA of '++'. They also explored the convergence of *ADI-R* performance with measures of adaptive, language, and cognitive functioning. Based on best fit indices, a two factor model solution was presented, consisting of social/communication items and restricted/repetitive behaviour items. This model was a better fit than the traditional three-domain model based on diagnostic criteria or a single 'autism' factor solution.

The dimensional structure of the autism phenotype was also investigated by Kamp-Becker, Ghahreman, Smidt, and Remschmidt (2009) in a small sample of high functioning individuals who attended their clinic for assessment. Two exploratory factor analyses were conducted, one on 'early development' data from the *ADI-R* and one on 'current presentation' data from the *Autism Diagnostic Observation Scale – Generic (ADOS-G*; Lord et al., 2000). This study received an OA of '+' due to their small sample size and exploratory focus. Factor analysis on the *ADI-R* supported a four factor solution. The first factor was named 'social communication' and explained approximately 17% of the variance, and combined items from the original social interaction and communication domains. The second factor was named 'anxiety and compulsions' and included circumscribed interests and verbal rituals. The third factor was characterised by 'stereotyped behaviour', both verbal and nonverbal. The final factor was described as 'inadequate behaviours'. Comparison of the autism and non-autism groups showed considerable difference between the 'social communication factor' and the 'anxiety and compulsions factor'.

Kamp-Becker et al. (2009) selected a five factor solution for factor analysis of the *ADOS-G* dataset, which accounted for 57% of the variance. The first factor covered 'social communication' items within a single sub-domain, explaining 26% of the variance. The second factor was named 'non/verbal behaviour' and included items influenced by eye contact and speech abnormalities. The third factor was named 'hyperactivity', fourth 'stereotyped behaviour' and fifth 'interests and compulsions'. Again, comparisons of the autism and non-autism group showed significant differences for the social communication factor as well as the non/verbal

factor. They concluded that the AS/HFA phenotype was structured by dimensions that differed to the conceptualisation of DSM-IV-TR criteria, particularly because the social interaction and communication domains were so closely related that they emerged as a single factor.

4. Discussion

The review highlighted a general lack of consistency about the number and structure of factors identified, and no definite agreement on the association between the social and communication elements of autism, and repetitive/restrictive behaviours and activities was found. When focusing on the studies that earned an OA of '++', two provide support for the existing DSM-IV stipulated structure of autism (Lecavalier et al., 2006; 2009). However, the latter study did report a strong correlation between social and communication scores. The remaining four studies varied in indentifying two (Frazier et al., 2008; Snow et al., 2009) or more (Georgiades et al., 2007; van Lang et al., 2006) factors. However, these four studies all reported social and communication items within the ADI as being accounted for by one combined factor. This could be read as some level of evidence in supporting a move towards differentiating the structure of autism into two domains – social-communication deficits and repetitive/restricted behaviours and activities.

The variation in findings could be explained at some level by the differences in design. No two studies had the same design, with different samples, age ranges and diagnoses, as well as different diagnostic tools being used. Populations included

in the analyses differed, with some studies including a broad range of autistic symptoms (e.g., Constantino et al., 2004) and others focusing on a narrow range of autistic traits, which could artificially inflate the association between symptoms and dimensions (Mandy & Skuse, 2008). Similarly, not all studies used data from the same questionnaire. As some questionnaires are designed as screening instruments to identify individuals with traits in need of further assessment, and others aim for definitive diagnosis, different questionnaires emphasise different core features. Different questionnaires were used across populations of varying cognitive ability. As discussed, factor analysis is sensitive to sample size, and even slight variations in sample composition and factor extraction criteria may give different results (Kline, 1994). However, using the quality criteria based on methodology identified the robust studies with more 'weight' behind them for consideration. It is however still worth remembering that the naming and interpretation of particular factors are dependent on the author's understanding of the data, which introduces a subjective element. Ideally, any measures used to reduce this potential bias would have been used as another quality criterion, but unfortunately there was not enough information reported within the identified papers to be able to do so.

The majority of studies reviewed used exploratory factor analysis (including principal components analysis) rather than confirmatory to investigate the structure of autism. As confirmatory factor analysis looks to assess the fit of a proposed model to see how well it captures the covariance between each item, it may be more suited to answering questions on the structure of PDD symptoms (Field, 2005). However, confirmatory techniques do require a larger sample size.

Understanding the structure of autism symptoms can improve diagnostic and classification systems, as it is possible that the three-domain conceptualisation of autism does not correctly describe the disorder. This could in theory contribute to unreliable diagnoses. By empirically examining the structure of autism symptoms, we can refine diagnostic procedures, as well as consider different phenotypes. The studies within this review examined the structure of ASD and were chosen as they included all three diagnostic criteria. Even within this sample however, the literature raises questions about differences in symptomatology in low and higher functioning individuals with ASD, and whether the separate symptom domains have different developmental trajectories.

Research has suggested that the severity of repetitive interest/behaviours is inversely correlated to IQ (Cuccaro et al., 2003, Szatmari et al., 2006) and Georgiades et al. (2007) found children with AS had high scores on the inflexible language and behaviour factor but low scores on the repetitive sensory and motor behaviour factor. Kamp-Becker et al. (2009) also found a significant correlation between their factor 'stereotyped behaviour' and performance IQ. It may be that there is a weaker relationship between social-communication symptoms and repetitive/restrictive behaviours and activities in high functioning people with ASD. Interestingly, Lecavalier et al. (2009) reported that different subgroups included in their analyses impacted the fit of their model. Samples of children with AS fit the DSM-IV-TR three factor model best, whereas data from children with a diagnosis of autism did not fit the model so well.

Future studies could continue to use factor analysis to examine the 'fit' of the autistic triad in low and higher functioning individuals with ASD, and consider whether the separate symptom domains have different developmental trajectories. However, despite three decades of exploration there is still no clear answer about the triad's empirical relevance. It may be that a wider exploration of areas of human development is required to capture all possible domains of impairment in individuals with ASD.

5. Conclusion

This review has suggested that although there are alternative ways to understand the structure of autism, the majority of the literature that looks at the triad of impairments suggests the symptom structure does not match that proposed by the DSM-IV-TR, and that the triad may no longer fit as the best way to conceptualise ASD. Instead, social and communication deficits show an association that suggests they should be considered together as a single domain, and repetitive/restrictive behaviours and activities considered as a separate symptom domain. Refining the structure of the autistic phenotype can provide valuable information for both diagnostic procedures and genetic research, as the identification of core symptoms might be useful in genetic linkage studies.

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1.3 Aims and Hypotheses

This thesis aims to test the strength of the association between the triad of impairments by using confirmatory factor analysis on data gathered from a group of adults diagnosed with AS or HFA using the Adult Asperger Assessment (AAA: Baron-Cohen *et al.*, 2005). The application of the current or newly proposed diagnostic criteria depends on the validity of the assumption that social and communication deficits and repetitive/restricted interests, behaviours and activities (RIBA) co-occur as three separate domains of impairment. Delineating the relationship between domains could shed light on the aetiological relationships with other traits or abilities. In this way, future studies of the neurobiological and genetic bases of autism could benefit.

To the best of the authors' knowledge, the AAA was designed using clinical experience rather than empirical data or statistical structure. There is no published information on the structure of the AAA. As there are well established theoretical models, this thesis aims to use confirmatory factor analysis to see which of the models proposed by theory is supported by the clinical data, rather than exploratory factor analysis which would be used to generate new models. The hypotheses are as follows;

(i) Confirmatory factor analysis supports the four factor structure originally proposed by the AAA authors (Baron-Cohen *et al*., 2005).

(ii) Confirmatory factor analysis supports the traditional DSM-IV-TR triad (APA, 2000).

(iii) Confirmatory factor analysis supports the proposed DSM-V dyad (APA, 2010).

Following confirmatory factor analysis, model modification will allow the content of the AAA to be explored in more detail.

1.4 Introduction Bridge, and Note on Terminology

Pervasive Developmental Disorders (PDD) is the umbrella term used to classify disorders on the autism spectrum within the DSM-IV-TR (APA, 2000). These are; Autistic Disorder (often referred to as autism), Asperger Disorder (AS), Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS; sometimes called atypical autism), Childhood Disintegrative Disorder and Rett's Disorder (APA, 2000). The definitions and boundaries of PDD have evolved since Kanner first reported an unusual condition which he labelled 'classic autism' (Kanner, 1943), and Asperger described a syndrome as 'autistic psychopathy' (Asperger, 1944/1991). Some authors prefer the umbrella term Autism Spectrum Disorders (ASD) rather than PDD, as it more clearly presents these conditions as a spectrum of related disorders, rather than a specific set of diagnostic labels (Phetrauwan *et al.,* 2009). Throughout this thesis, PDD and ASD are used interchangeably to represent the full spectrum of related disorders as described by current diagnostic manuals (DSM-IV-TR; APA, 2000; ICD-10; WHO, 1992).

The boundaries between the subtypes of ASD (in particular autism, AS and PDD-NOS) are unclear. They are conceptualised to share the triad of impairments in social skills, communication, and repetitive/restricted interests, behaviours and activities (RIBA). Most researchers consider them as a continuum of the same disorder, with varying degrees of symptom severity and intellectual functioning (Freitag, 2007). Diagnosis for ASD continues to rest entirely on recognition of these three core behaviours: qualitative impairment in social interaction, qualitative impairment in communication and RIBA (DSM-IV-TR; APA, 2000; IDC-10; WHO, 1992). Within AS, confusion arises around communication difficulties, with some authors highlighting clinical difficulties in prosody (Paul *et al.,* 2005) and pragmatic impairments (Landa & Goldberg, 2005), which are not required for diagnosis. There are, as yet, no definitive biological tests.

As covered in the systematic review, attention was really drawn to ASD with the publication of the DSM-III in 1980 (APA, 1980), after Rutter's influential review and generation of the 'Rutter criteria' (Rutter, 1978). Due to this relatively recent increase in awareness, professionals are now alert and informed of the possibility of children with ASD, and as a result there are a growing number of tools targeted for assessment and diagnosis. Currently, the 'gold standard' for assessment in childhood is the Autism Diagnosis Interview-Revised (ADI-R; Lord *et al.,* 1994) and the Autism Diagnostic Observation Schedule – Generic (ADOS-G; Lord *et al.*, 2000). However, these tools are time consuming to administer, complex, and require expensive training (Phetrauwan *et al.*, 2009). They are also not age-appropriate for adults born before the ASD watershed of the 1980s (Baron-Cohen *et al.,* 2005). Diagnosis of autism and AS in adulthood can be difficult, as they share many symptoms with other DSM-IV-TR disorders, such as schizoaffective disorder, obsessive–compulsive disorder and social anxiety disorder (Baron-Cohen & Wheelwright, 2004; Fitzgerald & Corvin, 2001; Klin *et al.*, 1995).

Stoesz *et al.* (2011) recently reviewed the literature for tools specifically used to assess adults for diagnosis of AS. They reported five tools; (i) Krug Asperger's Disorder Index (KADI; Krug & Arick, 2003); (ii) Gilliam Asperger's Disorder Scale (GADS; Gilliam, 2003); (iii) Ritvo Autism and Asperger's Diagnostic Scale-Revised (RAAD-S; Ritvo *et al.,* 2010); (iv) Asperger Syndrome (and high functioning autism) Diagnostic Interview (ASDI; Gillberg *et al.,* 2001); and (v) the Adult Asperger Assessment (AAA; Baron-Cohen *et al.*, 2005). They report that overall the normative information for each instrument is still relatively poor, and further research and development required before recommending one over another.

One of the tools reviewed, the AAA, is used clinically in the East of Scotland for diagnostic assessment, as it has been included in the diagnostic pathway within one of the local health-boards and used within the Regional Diagnostic Service. The AAA has been designed to assess adults for AS and high functioning autism (HFA), and is available free through the website of the Autism Research Centre, Cambridge. The AAA uses more stringent diagnostic criteria than the DSM-IV (Baron-Cohen *et al.,* 2005) but simplifies the difference between AS and HFA to the presence of a

language delay (HFA) or not (AS). Anyone who meets the AAA criteria will therefore also meet the DSM-IV criteria (Baron-Cohen *et al.,* 2005). Relevant items are displayed in Table 2, found in Appendix 2, within the structure proposed by the Baron-Cohen *et al*. (2005).

The AAA is completed by combining two screening instruments, the Autism-Spectrum Quotient (AQ: Baron-Cohen *et al.,* 2001) and the Empathy Quotient (EQ: Baron-Cohen & Wheelwright, 2004). The AQ comprises 50 questions assessing five different areas; Social skill, Attention Switching, Attention to detail, Communication and Imagination. The EQ comprises of 60 questions, of which 40 assess empathy and 20 are fillers. The AQ has been used as a research tool to assess autistic traits in individuals with normal intelligence (Baron Cohen *et al.*, 2001). It has also been found to predict diagnosis of AS in a clinical sample (Woodbury-Smith *et al.,* 2005), although is not designed to be a diagnostic instrument, rather to quantify the broader autism phenotype (Hoekstra *et al.*, 2011).

To the best of the author's knowledge, the factor structure of the AAA has never been empirically tested. There has been more empirical analysis of the AQ, mainly within general population samples. The AQ is not designed to fit the diagnostic triad of the DSM-IV-TR (and so did not meet inclusion criteria of the systematic review), but aims to qualitatively assess indices that are *related* to the triad of impairments, and incorporate aspects of cognitive impairments seen in the broader autistic phenotype. The five areas of the AQ, with each corresponding item, are described in Table 3 *(see Appendix 2)*.

As well as the structure described by its authors in Table 3, other research groups have explored the structure of the AQ to suggest alternate models. Austin explored the factor structure using data from a non-clinical student sample, to examine group differences and correlates with personality scales (Austin, 2005). Her results indicated either a single factor (explaining 14 per cent of the variance) or a three factor solution (accounting for 28 per cent of the variance). She linked the three factor solution into diagnostic criteria and named the factors social skills, details/patterns and communication/mind-reading. Austin reported that these three

factors were highly correlated to, and so supportive of, three of Baron-Cohen *et al.*'s originally proposed sub-scales; social skills, attention to detail, and communication. However, the communication sub-scale was not reliable, and only 26 of the AQ items had factor pattern matrix loadings greater than .4. She proposed a modified AQ, dropping items with a low factor loading, and moving a number of items between sections. She suggests more work on the subscales and items is required.

Hurst *et al.* (2007) also failed to find support for a five domain version of the AQ. Their exploratory factor analysis results closely matched the three factor solution of social skills, attention to detail and communication/mind-reading reported by Austin (2005). Hurst *et al.* suggest it would be prudent to try to establish these three factors rather than retain the original five, and delete items accordingly *(see Table 4, Appendix 2, for a description of the model proposed by Austin [2005] and Hurst et al., [2007]. Items that have moved domains are italicised)*. They report that the total AQ overall only marginally reached acceptable internal consistency, as did the social and attention to detail domains, indicating that the other subscales of attention switching, communication, and imagination domains did not reliably measure single constructs.

Two other studies have also examined the factor structure of the AQ. Hoekstra *et al.* (2008) used confirmatory factor analysis in a large general population and student sample. They identified a two factor model; a 'social interaction' factor and an 'attention to detail' factor *(see Table 5, Appendix 2).* This social interaction factor incorporated items from social skill, communication, imagination and attention switching domains. This could be linked to the proposed DSM-V amendments, in that social and communication items were better described by a single factor. Stewart and Austin (2009) resorted to exploratory factor analysis despite these suggested models, with a large student sample. Their analysis yielded a four factor model which they described as 'understanding others/communication', 'socialness', 'patterns/attention to detail' and 'imagination'. Their analysis suggested items be moved to different domains, and did not report items with a factor loading below .3 *(see Table 6, Appendix 2. Items that have moved domains have been italicised).*

Again, they reported that reliabilities for the overall scale were acceptable, but that the subscale structure required some revision (Stewart & Austin, 2009).

Given that these authors have found different factor structures for the AQ and each recommended revisions, it seems appropriate to examine the factor structure of the AAA as a diagnostic tool. As noted in the systematic review, confirmatory factor analysis is more appropriate when models exist *a priori*, rather than continual exploration of the data through exploratory factor analysis. This approach would also be timely given the new DSM-V dyad proposal, challenging the theoretical model of the diagnostic triad which has existed for some time. It therefore seems prudent to test these theoretical model, the triad and the proposed dyad of impairments, against data collected from a clinical sample. The validity of the current diagnostic criteria depends on the legitimacy of the assumption that social and communication deficits are separate domains of impairment. Delineating the relationship between domains in this way could shed light on the aetiological relationships with other traits or abilities, but could also be helpful in examining the diagnostic and assessment criteria used within each service.

2 METHODOLOGY

2.1 Chapter Summary

This chapter explains the research approach adopted in this study. The AAA (Baron-Cohen *et al.,* 2005) is further described and explored, as well as the research setting and context.

2.2 Design

2.2.1 Ethical Issues

The main ethical issue related to consent: the data had been collected as part of standard clinical practice, so consent from patients was not sought for this data to be used. However, the ethics committees of the National Health Service granted permission for the data to be used, conditional on approval from the relevant Caldicott Guardians, which was granted (*see Appendix 3 for Ethical approval)*. The project was also registered with the local NHS Research and Development Team and NHS Clinical Governance Team, as required by department policy.

Pre-existing Adult Asperger Assessment (AAA) scores were collected from closed files from the Regional ASD Consultancy Service and Local Clinical Psychology Department. The data were gathered retrospectively after assessment had been completed, and no contact with clients was required. Although a proportion of the assessments had been completed by the researcher, the majority of clients were seen by clinicians not associated with this research.

2.2.2 Recruitment of Clinicians and identification of cases

2.2.2.1 Regional ASD Consultancy Service

The Regional ASD Consultancy Service (RASDCS) is a multi-professional service covering South East Scotland. The service aims to provide diagnosis and advice to individuals over 18years old. Monthly allocation meetings provide an opportunity to discuss cases. RASDCS keeps a record on a database of all clients who are seen. The service administrator was able to identify clients who had attended for assessment and who received a diagnosis of AS/HFA. These closed service-specific files were then sourced within Medical Records across the health board area, and data collected (n = 140). Files of clients not diagnosed were not accessed.

2.2.2.2 Local Psychology Service

Local psychologists complete some ASD diagnostic assessments without referral to RASDCS. After Caldicott approval, an email was sent to Psychologists working within Adult teams across the area informing them about the study. Clinicians were then able to provide a list of clients who had met criteria for a diagnosis of AS or HFA. These closed files were then sourced from Psychology Records, and AAA scores collected (n = 13).

Clinicians from both services were informed that the results of the study would be submitted as this thesis and written up in journal format and submitted for publication.

2.2.2.3 Specialist Autism Research Centre in England

Strategies were in place to collect additional data from a specialist autism research centre in England. Unfortunately, due to staffing changes at the specialist research centre, this development was not possible, which resulted in a significantly smaller sample size than initially hoped. The initial data sharing agreement can be found in Appendix 4 *(see Appendix 4, further paper audit available via email chain).*

2.3 Procedure

2.3.1 Diagnosis

All clients were assessed for the presence of ASD according to DSM-IV-TR criteria by experienced clinicians, although the exact procedure varied depending on the clinician's training and case presentation (e.g. assessment by a psychologist might incorporate neuropsychological assessment, assessment by psychiatrists may include assessment of personality disorder or schizotypal psychopathology). Accordingly, cases were allocated on an assessment-needs basis. However, every client underwent clinical interview, and wherever possible an informant was sourced for developmental review. This was a semi-structured interview, ideally with a parent, which covered early development in all domains of autism spectrum conditions. This encompassed: birth history, medical history, family history, motor development, play behaviour, social behaviour, communication and other behaviour such as sensory sensitivities from 0-3 years. Each case was discussed at a multidisciplinary clinic before final diagnosis. However, although not dependent on AAA scores, diagnoses were not independent of assessment, as it was part of the battery used.

2.3.2 Data Collection

Relevant files were reviewed by the researcher, and data from the AAA was collected. The Data Recording Sheet had three sections *(see Appendix 5 for an example of the data recording sheet)*:

- Demographic details: Information was collected on gender and age.
- Raw AAA scores (both AQ and EQ scores).
- Unique identifier number. This acted as a code, linked to names of clients, to ensure the data could be traced back to client files if required. This information was not required for data analysis and was kept separately and securely, in line with data protection agreements and Caldicott guidelines.

The data were collected over a fifteen month period (beginning March 2010). The AAA was published in 2005, and the data gathered were from assessments from 2006 – 2011. Data were transferred from each file onto the data collection sheet. Names of patients, required as the key to unique identifier numbers, were kept separately and securely. The scores were then transferred into a Microsoft Excel spread sheet.

2.4 Materials

2.4.1 Adult Asperger Assessment (AAA)

As described in the previous chapter, the AAA is a diagnostic instrument designed to assess adults for diagnosis of AS and HFA. As the AAA is in the public domain, describing the questionnaire does not infringe copyright. However, permission from the author (Prof. S. Baron-Cohen) was sought as good practice *(See Appendix 6).*

The AAA is completed by combining two screening instruments, the Autism-Spectrum Quotient (AQ: Baron-Cohen *et al.,* 2001) and the Empathy Quotient (EQ: Baron-Cohen & Wheelwright, 2004). The client's response to each item on the AQ and EQ is entered into the AAA spreadsheet. A macro is run which scores 72 of the AQ and EQ items into one of four sections of the AAA; (i) qualitative impairments in social skills (Social); (ii) restricted repetitive and stereotyped patterns of behaviour, interest and activities (RIBA); (iii) qualitative impairments in verbal or nonverbal communication (Comm); and (iv) impairments in imagination (Imag). As described in the previous chapter, each item within the AAA can be seen in table 2 *(see Appendix 2).* The AQ and EQ responses form two functions; all the completed items are used to provide an overall score which can be compared to clinical cut-offs (Baron-Cohen *et al.,* 2005), but 72 of these are also used as examples of impairment within each section of the AAA (as described in the example AAA in Baron-Cohen *et al.,* 2005). This can then be used as the basis of a qualitative interview, and

directly compared to DSM-IV criteria. This thesis looks to examine the structure of ASD by examining data from these 72 items.

As previously described, although not all of them are used as examples within each section of the AAA, the AQ comprises 50 questions assessing five different areas; social skill, attention switching, attention to detail, communication and imagination *(see Table 3, Appendix 2 for the AQ items that correspond to each section).* These areas do not correspond to sections within the AAA, and some items are mixed from their AQ section into the domains stipulated by the AAA (i.e. AQ48 *'I am a good diplomat'* is in the social domain in the AQ, but in the communication domain in the AAA; AQ35 '*I am often last to understand the point of a joke*' is in the communication domain in the AQ, but in the social domain in the AAA). Items from attention switching and attention to detail are generally compressed into the RIBA section of the AAA, except item AQ10 *'In a social group, I can easily keep track of several different people's conversations'*, which transfers into the social domain within the AAA. After entering the AQ items into the AAA macro, 38 items are included in the AAA sections.

The EQ comprises of 60 questions, of which 40 assess empathy and 20 are filler items[1]. These filler items were excluded from data collection as they are control items only and do not contribute to the AAA score. The EQ is also designed to be a self-report questionnaire measuring an individual's beliefs about his/her own empathy. After entering the EQ items into the AAA macro, 34 items are included in the AAA sections.

[1] Filler items in the EQ are items 2, 3, 5, 7, 9, 13, 16, 17, 20, 23, 24, 30, 31, 33, 40, 45, 47, 51, 53 and 56.

Within the AAA, the individual's responses are scored on a 4 point Likert-scale on the AQ (1 = definitely agree, 2 = slightly agree, 3 = slightly disagree, and 4 = definitely disagree) and the EQ (1 = strongly agree, 2 = slightly agree, 3 = slightly disagree, and 4 = strongly disagree). These scores were used within this analysis, rather than the 0/1 or 0/1/2 scoring which is used to get the total score for the AQ and EQ respectively, to be compared to clinical cut-off figures (Baron-Cohen *et al*., 2005). Using the continuous Likert-scale retains more information about participants' responses (Stewart & Austin, 2009). This is helpful for factor analysis as utilises valuable information about the degree of endorsement for each item (Austin, 2005). Some of the items are reversed, with a 'disagree' response characteristic of ASD, so the data was transformed to account for this reverse scoring. Reverse scoring items are marked with an asterisk (*) throughout the thesis *(refer to Tables 2-7 in Appendix 2).* Within this thesis, higher scores on both the AQ and the EQ represent a higher autistic phenotype.

2.4.2 Reliability and Validity of the AAA

There have been no large-scale standardisation studies for the AAA (Stoesz *et al.,* 2011). The only published study presenting validity evidence for the AAA was with a small sample, reported by the authors (Baron-Cohen *et al.,* 2005). Forty two adults (31 with AS, 3 with HFA and 8 undiagnosed) were referred to the Cambridge Lifespan Asperger Syndrome Service (CLASS). Of the eight individuals who did not receive a diagnosis using the AAA, three met DMS-IV-TR criteria. The authors reported this reflected the fact that they designed the AAA to be more conservative than DSM-IV criteria (Baron-Cohen *et al.,* 2005). There has been to date no further published empirical evidence of the reliability of the AAA. It claims to have good content validity, in that it appears be consistent with symptoms and concepts in the literature (Baron Cohen *et al.,* 2005). However, to the best of the author's knowledge, no further empirical data on the complete AAA has been published.

2.4.2.1 Reliability and Validity of the AQ, as part of the AAA

There is more published research on the AQ. The test-retest and inter-rater reliabilities of the AQ have been shown to be good (Baron-Cohen *et al*., 2001; Ring *et al.,* 2008). The AQ has been found to be strongly predictive of a clinical diagnosis of AS according to DSM-IV-TR criteria (Woodbury-Smith *et al.,* 2005) and works cross-culturally (Hoekstra *et al.*, 2008; Wakabayashi *et al.*, 2006). Previous analysis has shown no significant age effect on AQ score (Hoekstra *et al.,* 2008). The authors have provided additional validity evidence based on significant differences between scores obtained from a group of adults with AS/HFA and typically developing males and females (Baron-Cohen *et al.*, 2001). They report that 80 per cent of individuals with AS/HFA tested scored above the cut off, compared to only two per cent of the control groups.

However, in terms of structure, the five domains of the AQ have been derived on a theoretical basis and clinical experience, and although the AQ has received more attention than the AAA, it has undergone relatively little empirical testing (Hoekstra *et al.,* 2008). In addition, the internal consistency coefficients of the AQ on the five domains have been reported to fall below minimum acceptable standards (Stoesz *et al.*, 2011).

2.4.2.2 Reliability and Validity of the EQ, as part of the AAA

The EQ has been shown to have good content validity, in that a panel of expert judges (experimental psychologists working in the field) all agreed each item of the EQ was shown to be related to a given definition of empathy (Baron-Cohen & Wheelwright, 2004). It has good test-retest reliability, and has shown a sex difference in empathy in the general population and an empathy deficit in AS/HFA (Baron-Cohen & Wheelwright, 2004). Cross-cultural validation of the EQ has shown satisfactory internal, convergent and discriminant validity (Berthoz *et al.*, 2008).

2.5 Participants

The data came from individuals who had used the services of the RASDCS between 2006 - May 2011 or the local Clinical Psychology Department between 2009 - May 2011 for assessment of ASD. All had received a diagnosis of AS/HFA. The sample can be regarded as opportunistic, but a true clinical population.

2.5.1 Sample size

The complete dataset was n = 153. However, if over 5 per cent of the data were missing in completed AQs and EQs, they were excluded from analysis (Tabachnick & Fidel, 2007). This left a dataset of n = 130. This sample consisted of 96 males and 34 females (male to female sex ratio of 2.8:1). The mean age for the sample was 33 years (SD = 11). There was no difference between the mean age of males or females ($p < 0.05$).

2.6 Analysis

2.6.1 Confirmatory factor analysis (CFA)

Factor analysis is a statistical approach that looks to explain the maximum amount of common variance in a correlation matrix, by using the smallest possible number of explanatory concepts (Field, 2000). If there is some knowledge of the underlying latent variable structure, confirmatory factor analysis (CFA) should be used rather than exploratory (Bryne, 2006). CFA explicitly tests *a priori* hypotheses about relations between observed variables (Jackson *et al.,* 2009). Thus, confirmatory factor analysis can be used to see which of the models proposed by theory is supported by the clinical data.

CFA models can be schematically portrayed as path diagrams (see Figure 1 for an example). The latent variables or factors are represented as circles (○; A in Figure 1), and the observed variables as rectangles (□; B in Figure 1). Arrows with

single heads (→; C in Figure 1) represent the impact of one variable on another, and factors can point to more than one observed variable. Once the variance caused by the latent factor is accounted for, all measures contain unique variance and measurement error (variance specific to that observed variable, and error variance; D and E in Figure 1). These unique factors are linked only to individual observed variables. Arrows with double heads (↔; F in Figure 1) represent covariances or correlations between pairs of variables. Factor loadings express the correlations of each observed variable with each factor. The squared factor loading (or communality) is the proportion of the variance of the observed variable that is explained by the factor.

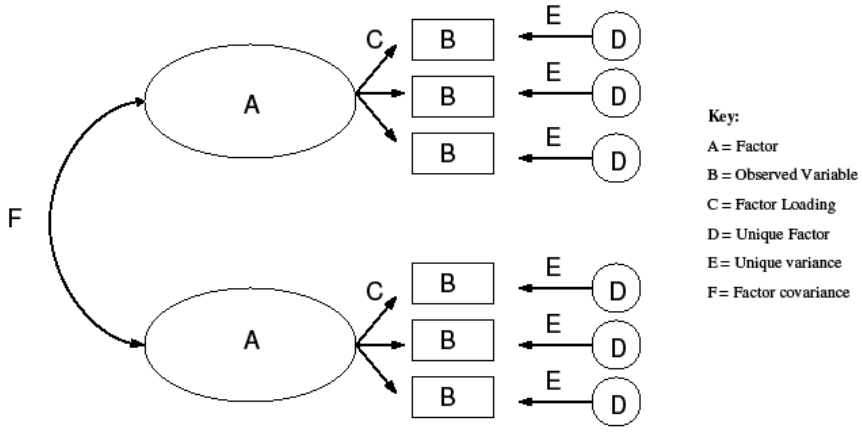

Figure 1. Example of a CFA Model

2.6.1.1 Sampling for factor analysis

There are a number of different views on the adequacy of the sample size required for factor analysis. The general rule of thumb is the more the better (Kline, 1994). Joreskog and Sorbom (1989) recommend a minimum N of 100, while a minimum N of 100 to 200 observations is also often recommended (Comrey, 1973,

1978; Gorsuch, 1983; Guilford, 1954; Hair *et al.,* 1995; Lindemen *et al.,* 1980). Others suggest that an adequate sample size can be assured with N - n - 1 > 50 (where N = number of participants and n = number of variables; Lawley & Maxwell, 1971).

Other authors typically recommend that the sample size should be determined as a function of the number of observed variables (N to *p* ratio rules), which vary from 2:1 to 20:1 (Baggely, 1982; Brislin *et al.,* 1974; Hair *et al.,* 1995; Lindeman *et al.,* 1980; Nunally, 1978). However, the most popular N to *p* ratio rules have not been substantiated (Guadagnoli & Velicer, 1988). Algebraically, it is essential that there are more subjects than factors (Kline, 1994).

Within this thesis, the sample size for the factor analysis of the AAA could be problematic, as it is smaller than would have been hoped. However, N > 100, and the sample meets the rule of N - n - 1 $\geq$ 50 (as described by Lawley & Maxwell, 1971). What is more, due to the unfortunate complications of procedure in gathering data from an additional site at Cambridge, the sample was as large as possible.

2.6.2 Software

Initially, EQS v6.1 Structural Equation Modelling Software (Bentler, 2007) was used to complete the confirmatory factor analysis. The author describes EQS as providing the most accurate known statistics for analysis on data that may not be multivariate normally distributed, such as clinical data (Bentler, 2007). Licences were available through the University of Edinburgh. However, output using this software resulted in multiple error messages, despite re-entering the data. After discussion with colleagues, another software system was explored, Mplus v5.21 (Muthvén & Muthvén, 2005-2011). Mplus also incorporates non-parametric test options to be used if the data does not have a normal distribution, and is supported by a free-to-access discussion forum for queries, answered by the authors.

2.6.3 AAA: Models tested

The models tested on the AAA data are depicted in Figure 2, in order to test each hypothesis. Domains were combined by including AQ and EQ items from the relevant sections (e.g. 'Communication/Social' included all the AQ and EQ items from both Communication and social skill sections).

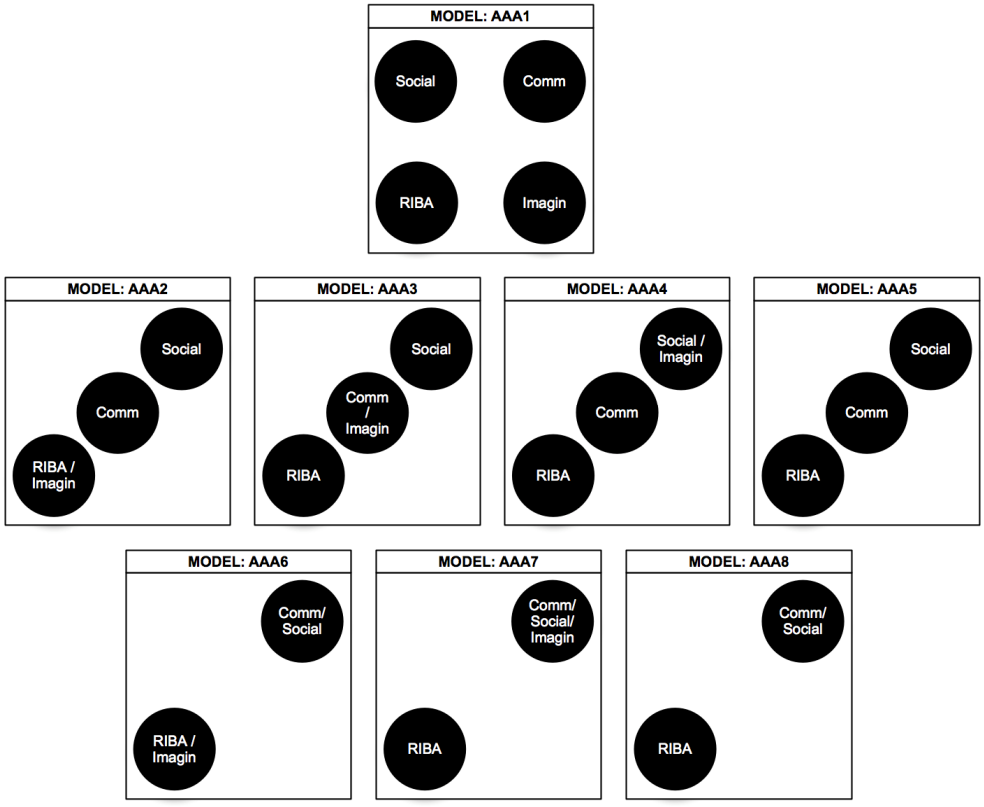

Figure 2. Brief schematic of models fitted to the AAA data

2.6.3.1 Note on Imagination

The AAA includes six items relating to imagination. Imaginative behaviours include activities ranging from simple pretend play to creative engagement with fictional stories. There is some debate over whether or not the concept of impaired imagination is linked to repetitive behaviour (as described by Wing & Gould, 1979)

or communication impairment as described within classification systems (APA, 2000; WHO, 1992). As described, these diagnostic systems provide a separate category for RIBAs, and categorise impairments in imagination as part of the communication deficits for ASD. However, explorative factor analytic studies have suggested a three way association between repetitive behaviour, imagination and communication (Honey et al., 2007). Imagination was therefore included in each domain for each hypothesis.

2.6.3.2 Hypothesis 1 - Four Factor solution

The first hypothesis tested was that CFA would support Model AAA1, the four factor solution as suggested by the authors of the AAA (Baron-Cohen *et al.*, 2005). This model stipulated four separate domains; (i) qualitative impairments in social interaction (Soc); (ii) Restricted, repetitive and stereotyped patterns of behaviour, interests and activities (RIBA); (iii) Qualitative impairments in verbal or non-verbal communication (Comm); and (iv) Impairments in imagination (Imag). These domains, and the AQ and EQ items that correspond to each, are displayed in Table 2, Appendix 2.

2.6.3.3 Hypothesis 2 - Three factor solutions; the triad of impairments

The second hypothesis was that CFA would support the triad of impairments. Model AAA2 was the three factor 'triad' of impairments as stipulated by current diagnostic criteria, but included imagination as a function of RIBA (RIBA/Imag). Model AAA3 again used the triad, but with imagination as a function of communication (Com/Imag). For completeness, and considering the debate about the proposed overlap between social and communication symptom domains, Model AAA4 used the diagnostic triad but with imagination as a function of social skills (Soc/Imag). Model AAA5 was tested as the DSM-IV-TR described triad ('communication', 'social' and 'RIBA' factors), excluding all items that corresponded to imagination.

2.6.3.4 Hypothesis 3 - Two factor solutions; the diagnostic dyad

The final hypothesis was that CFA would support the newly proposed diagnostic 'dyad' solution, as proposed by changes to DSM-V diagnostic criteria. The final models combined social and communication impairments as a single symptom domain (Com/Soc). Model AAA6 used this domain along with imagination as a function of RIBA (RIBA/Imag) and Model AAA7 included imagination as a function of this single 'social/communication' factor (Com/Soc/Imag). Model AAA8 was the newly proposed DSM-V dyad ('communication/social' factor and RIBA), excluding all Imagination items.

2.6.4 Goodness of fit indices

As discussed, CFA explicitly tests a priori hypotheses between observed variables and latent factors. It is the analytic tool of choice for exploring structure when theories already exist, rather than exploratory factor analysis (Jackson *et al.,* 2009). It is also therefore an appropriate tool in developing and refining measurement instruments (Jackson *et al.,* 2009). CFA is used to evaluate model adequacy by examining the discrepancy between an implied correlation matrix and the actual observed matrix (DeCoster, 1998). The amount of discrepancy between these two matrices can then be used as a measure of how consistent the model is with the data (DeCoster, 1998). These are known as goodness of fit indices. There are numerous indices of global fit, such as the chi-square goodness-of-fit test, the comparative fit index (CFI; Bentler, 1990) and the root-mean-square error of approximation (RMSEA; Browne & Cudeck, 1993), but also indices of fit which have different properties (Jackson *et al.*, 2009). Hu and Bentler (1998) recommend relying on fit indices that have different measurement properties, such as incremental fit indices (for example, the CFI) and residual-based fit indices (such as the standardised root-mean-square residual [SRMR]; Bentler, 1995; Joreskog & Sorbom, 1986). Other fit indices have been proposed and shown to perform well in smaller samples (e.g. Tucker-Lewis index [TLI]; Tucker & Lewis, 1973).

Adding to the complexity of choosing how to evaluate model fit, recommendations for cut-off values for some indices have changed over time (Jackson *et al.*, 2009). Bentler and Bonet (1980) developed incremental fit indices that offered an evaluation of how a model fits observed data on a scale of 0 to 1. They proposed incremental fit indices of .9 or higher reflected acceptable levels of fit. This was revised by Hu and Bentler (1999), who recommended a cut-off of .95, whereas Schermelleh-Engel *et al.* (2003) recommended .97. Other research argued for the use of indices based on a standardised measure of discrepancy between the fitted covariance matrix and the sample covariance matrix, based on the work of Steiger and Lind (as cited in Marsh *et al*., 2004). The lower limit of these indices is zero, and they have no upper limit. Experience led researchers to suggest that, with these indices of discrepancy, a cut-off of .05 or below is indicative of a close fit, but values up to .08 represent reasonable errors of approximation (Marsh *et al*., 2004). However, it is worth noting that goodness of fit indices only provide rules of thumb, and there are no "golden rules" in interpreting this type of data analysis (Marsh *et al.,* 2004). Interpretation is subjective, and must be reported as so.

Within this thesis, Jackson *et al.*'s reporting checklist (2008) guided the inclusion of multiple fit indices; MLM chi-square (also known as the Sattora-Bentler chi-square [Satora & Bentler, 2001]), the comparative fit index (CFI; Bentler, 1990), the Tucker-Lewis Index (TLI; Tucker & Lewis, 1973), the root-mean-square error of approximation (RMSEA) and the standardised root mean square residual (SRMR). Cut-off 'rules of thumb' were based on Hu and Bentler (1999). In the case of CFI and TLI, values above .95 indicated a good / acceptable fit; RMSEA of .06 or less; and for the SRMR values of .08 or less were desired *(see Table 7).*

Table 7. Goodness of fit indices: Rules of thumb cut-offs.

	CFI	TLI	RMSEA	SRMR
Cut-off	> .95	> .95	< .06	< .08

3 RESULTS

3.1 Evaluation of Assumptions for CFA

SPSS version 17.0 was used to assess the suitability of the data sets for analysis (Tabachnick & Fidell, 2007). These are outlined below. Descriptive statistics by subtest for each item of the AAA are provided in Table 8 *(see Appendix 7)*. This was used to check for outliers to correct any data entry errors.

3.1.1 AAA: Multicollinearity, Sample size and normality

The correlation matrix was checked for multicollinearity and singularity by using the Kaiser-Meyer-Olkin (KMO) test of sampling adequacy and the Bartlett test of sphericity. The KMO indicates whether or not the associations between variables in the correlation matrix can be accounted for by a smaller set of factors (Ferguson & Cox, 1993). Values between .5 and .7 are acceptable but mediocre for factor analysis (Field, 2000), with a minimum value of .5 being required (Dziuban & Shirkey, 1974). The KMO of the AAA data was .667.

Bartlett's test of sphericity is based on the variance-covariance matrix. This tests the null hypothesis that no relationship exists between any of the variables (Ferguson & Fox, 1993). Bartlett's test for the AAA data was highly significant ($p < 0.001$), indicating there were 'discoverable' relationships within the data. Given that both Bartlett's and the KMO measure were within reasonably acceptable limits, factor analysis was considered to be an appropriate way to explore the dataset.

3.1.1.1 Further Exploration of the data

As mentioned previously *(see Section 2.6.2),* difficulties with the initial software prompted the sourcing of another factor analytic computer programme. In order to try and account for the difficulties in running the initial CFA, a Spearman's correlation was carried out on all the items of the AAA. The correlation matrix indicated that none of the individual items were highly correlated (Spearmans r < .7). However, when examined more closely, the correlation matrix suggests there were some pairs where r = .000. Scatter plots suggested no relationship was present. Some of these pairs came from the same domain. Examples of these pairs are displayed in Table 9.

Table 9. Examples of pairs of AAA items from the same domain (r = 0.000)

Item 1	Item 2	r	*p*
A38.I am good at social chit-chat (Comm)	EQ46. People sometimes say I have gone too far with teasing. (Comm)	0.000	0.998
EQ32. Seeing people cry doesn't really upset me (Social)	EQ55. I can tell if someone is masking their true emotion (Social)	0.000	0.999
EQ57. I don't consciously work out the rules of social situations* (Social)	EQ26. I am quick to spot when someone in a group is feeling awkward or uncomfortable* (Social)	0.000	0.996

From a total of 153, N = 128 datasets had been compiled with < 5 per cent of data missing. Despite this loss of data, this sample had more participants than expected factors (32.5:1; above the minimum ratio of 20:1; Kline, 1994), but only had a ratio of participants to variables of 1.8:1, below the suggested minimum of 2:1 (Kline, 1994). However, further inspection of the data showed that although < 5 per cent of the data were missing, the dataset did contain missing individual items. Missing Values Analysis in SPSS showed that this data was missing at random. T-

tests were not required as data with > 5 per cent missing values had already been removed, and the next highest missing value was within reasonable limits at 3 per cent. Some tests can accommodate missing data by using maximum likelihood estimates, assuming the data are randomly missing and the sample represents a normal distribution.

In order to see if these procedures could be used, normality for each item was assessed by calculating standardised scores for skewness and kurtosis by diving each score by its standard error (Field, 2000). Any value above 1.96 suggests the distribution of scores is non-normal (Field, 2000). Kurtosis allows the measurement of the peaked-ness of the distribution curve, with a positive value representing a sharply peaked distribution, and negative value suggesting the distribution is flat. Skewness is a measurement of the symmetry of the distribution. A negative skew z score suggests a distribution of data with relatively few low values (i.e. more high scores within the dataset, where the mean would not be in the centre of the distribution), where a positive skewness z score suggests data of very few high values and more low values *(see Table 12, Appendix 8)*.

The significant z scores suggest that the responses do not follow a normal distribution. As the sample deviated significantly from a normal distribution, it was felt that maximum likelihood imputation was not appropriate. This led to the development of robust algorithms for CFA and covariance modelling that does not rely on normal distribution. However, of note is that a factor analysis solution can be degraded if the variables are non-normal in different ways as in the AAA items (i.e. some positively and some negatively skewed) so further analysis needs to be treated with caution (Tabachnick & Fidell, 2007).

Yuan and Bentler (1998) suggest that in fields such as psychology when data does not always meet assumptions of multivariate normality, it is not always appropriate to use normal theory methods which can distort the results. As the sample is purely clinical it is perhaps not surprising that the data do not have a normal distribution. All participants have met diagnostic criteria for AS/HFA so would be expected to score highly (towards the 'more autistic' phenotype). This would explain the many negatively skewed items. It is more interesting to consider

the AAA items that do not show significant negative skew, as these suggest more of a range in responses within the diagnosed population (i.e. AQ9; *I am fascinated by dates*; EQ11; *It doesn't bother me too much if I am late meeting a friend).*

A Kolmogorov-Smirnov test suggested that all the AAA items differed significantly from a normal distribution ($p \leq .001$, for all items). This may have been expected given that data distribution from a clinical population may not be expected to be normal (Tabachnick & Fidell, 2007). As the data did not have a normal distribution, a non-parametric test MPlus v5.21 (Muthén & Muthén, 1998-2011) was used to run the confirmatory factor analysis on the correlation matrix. In models with data which are considered multivariate, maximum likelihood mean (with standard errors and a mean-adjusted chi-square test statistic robust to non-normality; MLM) is typically used to estimate the models. The MLM chi-square test statistic is also referred to as the Satorra-Bentler chi-square. Unfortunately, MLM in MPlus uses a list-wise procedure to deal with missing data, further reducing the dataset (n = 110). As there are 72 items being examined within the AAA, this means there is a ratio of participants to variables of 1.5:1, but still minimum ratio of 27.5:1 for variables to factors (based on the maximum four factor model being tested). This means there is a high likelihood that there are not enough participants for the number of items within the questionnaire, and results need to be treated with caution.

3.2 Model estimation for the AAA

CFA allows the researcher to compare the discrepancy between the implied correlation matrix of the model tested, and the actual observed matrix within the data. Goodness of fit indices are produced, and relevant figures as stipulated in the Methodology section (section 2.8) can be seen in Table 11: AAA model estimation.

Table 11. AAA Model estimation, with goodness of fit indices and rules of thumb.

	MLM χ^2	CFI > .95	TLI > .95	RMSEA < .06	SRMR < .08
AAA1	4730.36	.415	.397	.091	.117
AAA2	4827.22	.391	.372	.093	.118
AAA3	4753.88	.410	.392	.091	.116
AAA4	4752.81	.410	.392	.091	.116
AAA5	4071.92	.428	.409	.093	.118
AAA6	4840.44	.388	.370	.093	.118
AAA7	4765.65	.407	.390	.091	.117
AAA8	4087.74	.424	.406	.093	.119

As can be seen from Table 11, none of the models were supported by the data (CFI and TFI < .95, RMSEA > .6, SRMR > .08). Therefore none of the hypotheses were supported. The most frequent tool for comparing models is the chi-squared difference test. Recently however, some researchers have questioned whether this should be used, given the chi-square's sensitivity to deviations of fit (Cheung & Rensvold, 2002). Instead, differences can be examined in the practical fit indices. A change in CFI (ΔCFI) of .01 to .02 is indicative of differences between significant models, with definitive differences when ΔCFI is greater than .02 (Cheung & Rensvold, 2002, validated by Chen, 2007). However, these differences are not valid in models with non-significant and poor overall fit.

The most supported model (based on the best fitting CFI), although still poor, is AAA5. This model was designed on the traditional DSM-IV-TR triad model of social skills, communication and RIBA, and ignores AAA items that relate to the Imagination factor. The next was AAA8, the proposed dyad of Social and communication impairments as a single factor, and RIBA as a separate 'non-social'

factor. Again, this model ignores the AAA items that relate to the Imagination factor. However, there is not currently a way to decide on the meaningfulness of any difference in fit indices (i.e. a difference in RMSEA values) care must be taken not to over-interpret small difference in fit indices. Path diagrams of AAA5 and AAA8 can be seen in Figures 3 and 4. The factor loadings of the other models tested can be found in Table 12-17, Appendix 9.

3.2.1 Interpreting Factor Loadings

Views on the requisite size of loading vary depending on the data, and some consider a loading of .6 high and those below .4 low (Hair *et al*., 1995). Hu and Bentler (1999) recommend .35 as the acceptable minimum level. R^2 expressed as a percentage shows how much of the variance of each factor is explained by each item. Thus, a loading of .3 is equivalent to 9% of the variance in the indicator variable being explained by the factor. Figures and 3 and 4 highlight items with loadings below the acceptable minimum, and identify potentially problematic items within the AAA. These are detailed in Figure 5.

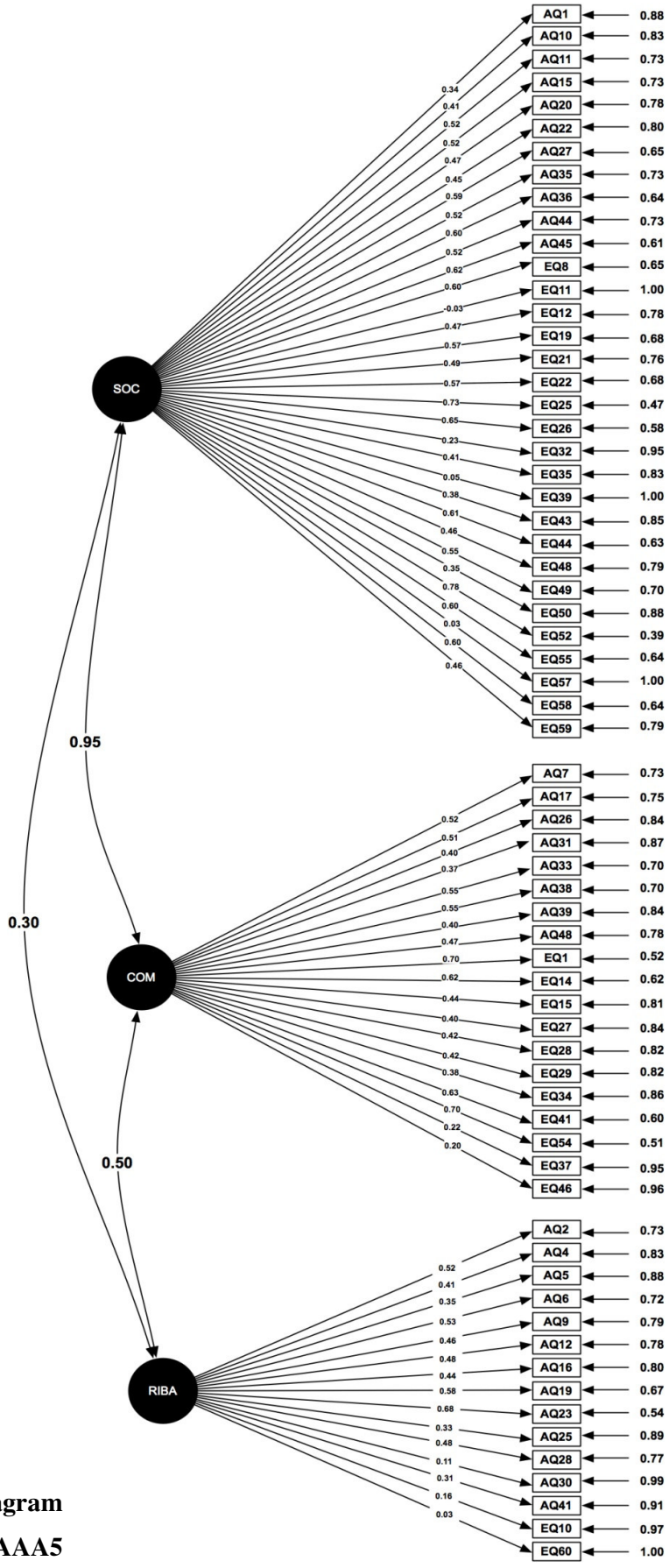

Figure 3: Path diagram of Model AAA5

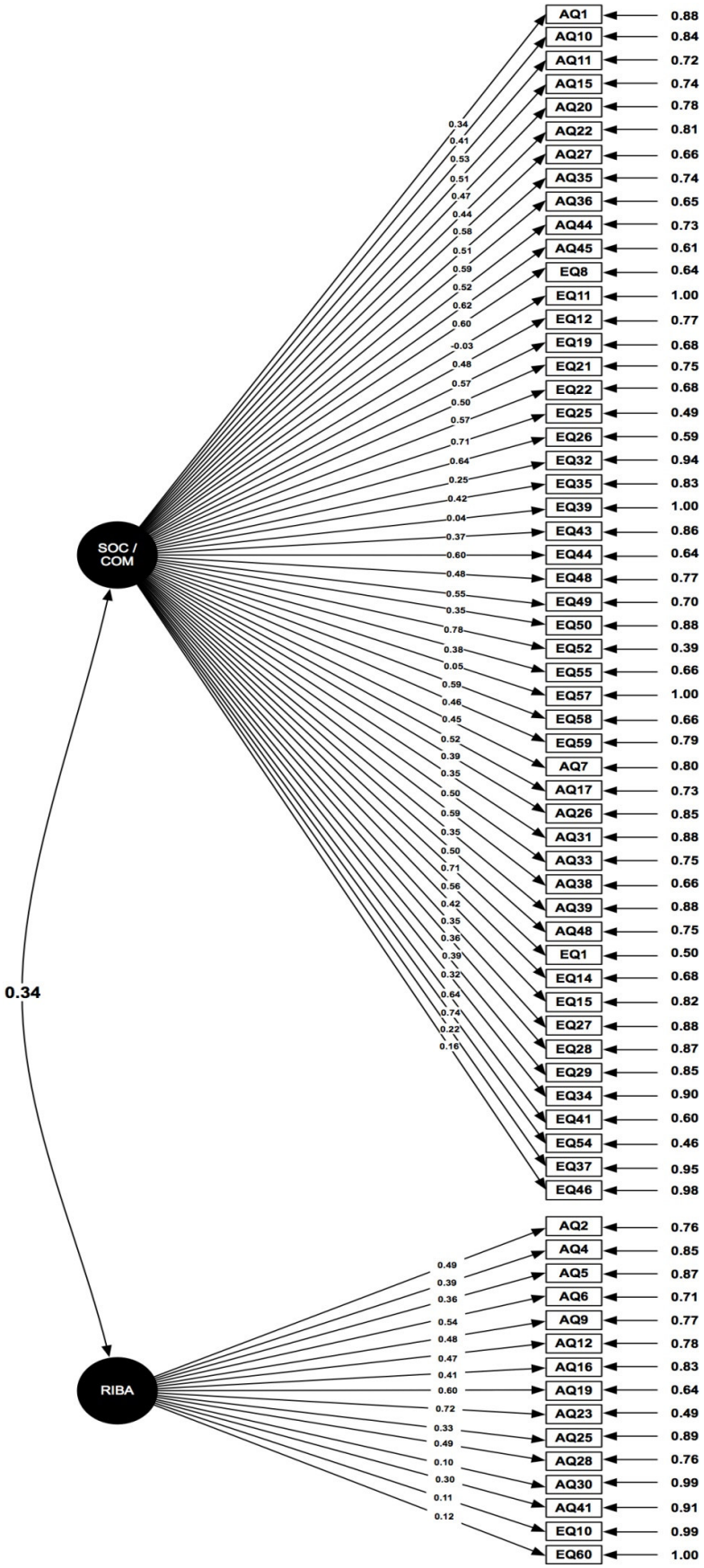

Figure 4: Path diagram of Model AAA8

Items relating to Social difficulties

AQ1. I prefer to do things with others rather than on my own

EQ11. It doesn't both me too much if I am late meeting a friend.

EQ32. Seeing people cry doesn't really upset me

EQ39. I am able to make decisions without being influenced by people's feelings

EQ50. I usually stay emotionally detached while watching a film

EQ57. I don't consciously work out the rules of social situations*

Items relating to Communication difficulties

EQ34. I am very blunt, which some people take to be rudeness, even though it is unintentional

EQ37. When I talk to people, I tend to talk about their experiences rather than my own*

EQ46. People sometimes tell me that I have gone too far with teasing.

Items relating to RIBA

AQ5. I often notice small sounds when others do not.

AQ25. It does not upset me if my daily routine is disturbed.*

AQ30. I don't usually notice small changes in a situation, or a person's appearance.*

AQ41. I like to collect information about categories of things (e.g. types of car…)

EQ10. People often tell me that I went too far in driving my point home in a discussion

EQ60. I can usually appreciate the other person's viewpoint, even if I don't agree with it*

Items relating to Imagination

AQ14. I find making up stories easy*

AQ21. I don't particularly enjoy reading fiction.

Figure 5. Non-significant items, with a factor loading < .35

3.2.2 Exploring the Content Validity of the AAA: Model modification

Following CFA on each model, MPlus is able to suggest modifications to increase the fit indices. In order to explore the content validity of the AAA (rather than test the factor structure hypotheses), these modifications were implemented. Items which had a poor factor loading (i.e. factor loading $\leq .35$) and that were not significant ($p > .05$) were removed from analysis, and items that impacted factor loading were transferred. Although this does not directly inform the research question of the structure of autism, it does raise some interesting questions about the AAA, as the same items were flagged repeatedly *(see Figure 5)*. Removing these

items increased the fit of each model (see Table 18). However, altering models to improve fit means researchers may unintentionally capitalise on chance, so the modified models may not generalise to other samples.

Table 18. Model modification: Removal of non-significant and low-loading items within the AAA.

	MLM χ^2	CFI > .95	TLI > .95	RMSEA < .06	SRMR < 0.8
AAA1	2788.596	.551	.532	.085	.104
AAA2	2775.572	.529	.510	.087	.112
AAA3	3045.507	.526	.509	.086	.105
AAA4	3046.006	.526	.508	.086	.105
AAA5	2507.086	.548	.529	.088	.106
AAA6	2484.220	.562	.544	.083	.111
AAA7	2595.004	.575	.559	.081	.099
AAA8	2497.645	.549	.531	.087	.107

As can be seen in Table 18, implementing the modifications and removing items that were non-significant ($p > .05$) with low factor loading (< .35) slightly improved the fit of each model, although again none were near meeting acceptability criteria. When these items were removed, the modified model with fit indices closest to rules of thumb (CFI, TLI and RMSEA) was model AAA7, the dyad, which combined communication, social and imagination deficits into one single factor, and left RIBA as a separate factor *(see Figure 6).* Item AQ28 '*I usually concentrate more on the whole picture rather than the small details**' was transferred from the RIBA domain onto the larger 'communication/social/imagination' factor.

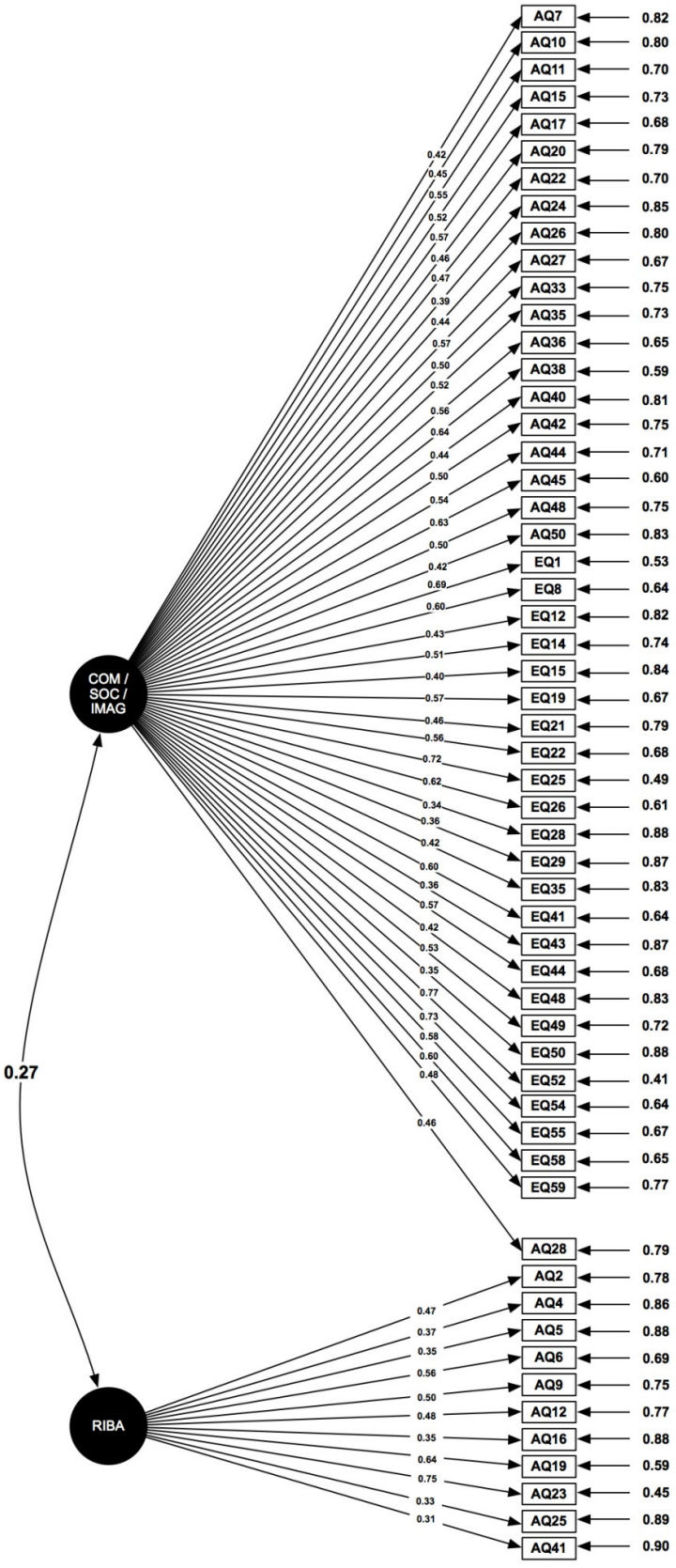

Figure 6: Path Diagram of Modified Model AAA7

3.3 Reliability and Correlations between items

3.3.1 AAA

Correlations between each factor identified within each model tested can also be considered. MPlus highlights how each factor correlates with each other factor stipulated in the model. As described in Figure 1, Chapter 2.6.1, correlations between domains are displayed in path diagrams (see Figures 3, 4, and 6). In each of the models tested on AAA data, Social and Communication factors correlated highly ($r > .9$, $p < .01$) (see Table 19, correlations over .7 are highlighted in bold). This suggests that it may not be plausible to separate the Communication and Social factors in each of the models fitted to the data. There was also a moderate correlation between the Communication factors and Imagination factors in the four factor model ($r = .686$, $p < .01$), and in the three factor model when imagination items and RIBA items were fitted as a single domain ($r = .708$, $p < .01$). There was a lower correlation between the Communication factors and RIBA when Imagination items were not grouped together ($r = .503$, $p < .01$).

Table 19. Factor Correlations within each AAA Model

Model	Correlating factor	With…	r	p ≤
AAA1	RIBA	SOCIAL	.271	.001
	COMM	SOCIAL	**.958**	.001
		RIBA	.462	.001
	IMAG	SOCIAL	**.705**	.001
		RIBA	.210	.001
		COMM	.686	.001
AAA2	RIBA/IMAG	SOCIAL	.530	.001
	COMM	SOCIAL	**.954**	.001
		RIBA/IMAG	**.708**	.001
AAA3	RIBA	SOCIAL	.263	.001
	COMM/IMAG	SOCIAL	**.961**	.001
		RIBA	.429	.001
AAA4	RIBA	SOC/IMAG	.277	.001
	COMM	SOC/IMAG	**.960**	.001
		RIBA	.465	.001
AAA5	RIBA	SOCIAL	.295	.001
	COMM	SOCIAL	**.947**	.001
		RIBA	.503	.001
AAA6	RIBA/IMAG	COMM/SOC	.612	.001
AAA7	RIBA	COMM/SOC/IMAG	.316	.001
AAA8	RIBA	COMM/SOC	.340	.001

4 DISCUSSION

4.1 Chapter Summary

This chapter begins by interpreting the results.

The aim of this study was to add to the literature on the structure of autism, by seeing if confirmatory factor analysis on clinical data would support one of three proposed hypotheses, based on the pre-existing theoretical constructs;

(i) Confirmatory factor analysis would support the four factor structure originally proposed by the AAA authors (Baron-Cohen *et al*., 2005), as depicted in model AAA1.

(ii) Confirmatory factor analysis would support the traditional DSM-IV-TR triad (APA, 2000), as depicted in models AAA2-5.

(iii) Confirmatory factor analysis would support the proposed DSM-V dyad (APA, 2010), as depicted in models AAA7-8.

The implications of these results will be discussed within this chapter, as well as examining the wider clinical and theoretical implications of the findings, the limitations of the research, and suggestions for future research.

4.2 Results of the confirmatory factor analysis

Confirmatory factor analysis (CFA) seeks to confirm a structure already proposed by previous analyses and theoretical constructs. For this reason, it is more powerful than exploratory factor analysis when theories already exist, as the models identified by theory can be assessed for their ability to account for the observed data (Bryne, 2006). Confirmatory factor analysis was therefore used to see if data from a clinical population of adults diagnosed with AS and HFA supported the four factor model initially proposed by the authors of the AAA (Baron-Cohen *et al.*, 2005), the traditional DSM-IV triad, or the newly proposed DSM-V dyad (hypotheses 1, 2 and 3 respectively). As the AAA also has items relating to 'Imagination', these items were incorporated into each domain of the triad and dyad.

None of the models tested could account for the data, as none met the goodness-of-fit rules of thumb of CFI > .95, TLI > .95, RMSEA < .06 or SRMR < .08. The research hypotheses of proposed theoretical structures, despite being drawn from existing theory, could not be supported by CFA on the clinical dataset.

The models closer to the goodness-of-fit rules of thumb were those that excluded all of the imagination items from the analysis: the traditional triad of social skills, communication and RIBA, and the proposed dyad of a joined social-communication factor and RIBA *(Figures 3 and 4, Section 3.2)*. However, as neither model met the goodness-of-fit ratios it is not meaningful to compare the fit between the two. The fact that removing Imagination items from the AAA allowed the models to account for more of the data raises the possibility that there may be issues with the content validity of the AAA scale. Similarly, model modification suggested by the confirmatory factor analysis software highlighted that more variance could be accounted for by removing items detailed in Figure 5. Interestingly, many of these items had been previously flagged as potentially problematic items: EQ32 *'Seeing people cry doesn't really upset me'*, EQ46 *'People sometimes tell me that I have gone too far with teasing'*, and EQ57 *'I don't consciously work out the rules of social situations*'* had been noted not to correlate with other items within their own domain *(Table 9, Section 3.1.1)*. Another low-loading item EQ11 *'It doesn't bother me too*

much if I am late meeting a friend' did not show the expected negative skew when testing for normality (*Table 10, Appendix 8*). This suggests that despite this being a clinical sample diagnosed with AS or HFA, the majority of clients did not score highly (towards the typical 'autistic phenotype') on this item. Fit was also improved by moving one of the items AQ28 '*I usually concentrate more on the whole picture rather than the small details*'* from the RIBA domain onto the other factor. When these and the other items detailed in Figure 5 were removed, the best fitting model was AAA7, the dyad that incorporated communication, social and imagination domains into a single factor, and RIBA as a second *(Figure 6, Section 3.2)*. This could in theory be similar to the 'social' and 'non-social' factor structure described by the high OA rated papers in the systematic review and the forthcoming DSM-V. However, model modification should be done sparingly and only when the modifications are theoretically and practically plausible, as it may capitalise on chance variations within the sample (Jackson *et al.*, 2009). The queries surrounding these particular items are theoretical in nature until the models can be cross-validated on an independent sample.

Analysis of the correlations between factors also provided evidence of potential pitfalls in considering social and communication factors as separate domains that requires further exploration. In all the AAA models fitted to the data, communication and social factors were generally very highly correlated ($r > .9$, $p < .001$, *Table 19*, *Section 3.3.1*). This suggests overlap between the variance explained by each factor. The lower correlations between social and RIBA factors could also suggest strength in the dyad structure being proposed. The nature of social and communication deficits seen within ASD suggests some correlation is likely, but it may be that AAA items relating to social and communication deficits are actually tapping into the same thing.

4.3 Summary of results

None of the models fitted to the AAA data met the goodness-of-fit rules of thumb, thus none of the hypotheses were supported. The results of the confirmatory

factor analyses are therefore limited in shedding further light on the debate on the structure of autism.

As always, these results can only be generalised to the sample that was used to estimate and test the model (Tabachnick & Fidell, 2007). Statistical methods do not give the 'correct answer', but indicate how 'far off' the observed data are in relation to specified theoretical models (Lecavalier *et al*., 2009). The reported high correlation and potential overlap between social and communication factors seems to make sense clinically: impaired communication in ASD exists across a broad spectrum affecting both verbal and nonverbal impairments (Cashin & Barker, 2009). Thus, particularly nonverbal communication deficits such as difficulties with facial expression and gesture are clearly going to have social ramifications.

However, it does seem likely that this aspect of the AAA requires further assessment. It is currently used clinically as a diagnostic tool, however, as the current research has not found evidence for the four factor structure proposed by the authors (Baron-Cohen *et al.,* 2005) and suggested some items do not account for significant amounts of the variance within each factor, questions could be raised regarding its content validity.

4.4 Limitations with this research

The impact that differences in sample, instrument and procedure have on factor analytic studies was outlined within the systematic review (Lecavalier *et al.,* 2009), and these are described within this section as potential limitations.

4.4.1 Sample Size and non-normal distribution

Results of this study need to be treated with caution due to methodological difficulties. The limited sample size in the CFA of the AAA particularly is disappointing. At the beginning of the project, there was good reason to believe that a large enough data set could be collected due to numbers of previous referrals, but

unfortunately missing data and difficulty locating some closed files meant the final number of completed AAA forms was lower than expected. This, coupled with the loss of the extra data set from the Specialist Autism Research Centre, meant that there was significantly less data than was hoped for. There are no clear guidelines on the size of a sample suitable for factor analysis, although the general rule of thumb is the more data the better (Kline, 1994). Other recommendations vary from $N - n - 1 \geq 50$ (where N = number of participants and n = number of variables; Lawley & Maxwell, 1971), N at least 100 (Gorsuch, 1983), to a rating scale where 100 = poor, 200 = fair, 300 = good, 500= very good, 1000 or more = excellent (Comrey & Lee, 1992).

Kline (1994) describes these difficulties with numbers required for reliable results as one of the problems in using CFA. In the present study, the criteria of $N - n - 1 \geq 50$ was met for the AAA data at the beginning of analysis, but unfortunately this fell under this threshold when missing data was registered. Although some tests can accommodate missing data by using maximum likelihood estimates, the sample needs to represent a normal distribution. This was not the case with the clinical sample, so a robust non-parametric model estimation procedure needed to be used. This resulted in loss of some participants. Missing data is one of the difficulties in using 'real' clinical records, and one of the most pervasive problems in data analysis (Tabachnick & Fidell, 2007). However, the dataset was still over 100, and essentially there were more subjects than factors (Kline, 1994). This study is the first to consider the structure of ASD by using AAA data from a clinical population, and used true clinical data. Even with the limitations of sample size, it has highlighted that more research is required both on this diagnostic tool, but also on the conceptualisation of ASD with this population.

4.4.2 Sample characteristics

Uncertainly still exists as to whether or not AS differs meaningfully from HFA (Rutter, 2011). They are generally considered to be distinguishable by the presence of an early delay in language acquisition (HFA) or not (AS). It could be that

in the future if differences are delineated, the factor structure could differ for each sub-type. Within the present study, there was no consistent clarification as to whether each client had been diagnosed with AS or HFA as clinically, they are treated as a single group, so the sample was treated a single subgroup within the analysis.

As described, the sample was clinical, and every client had been diagnosed with AS/HFA. The majority of analyses on the AQ have been carried out with student samples, so using a clinical sample should be considered a strength of the study. However, there was an awareness that, by only including individuals who met diagnostic criteria, the association between symptoms could be artificially inflated (Mandy & Skuse, 2008). Happé *et* al. (2006) describe one of the challenges in establishing the association between symptom domains as the "circularity of examining diagnosed populations" (p1218). As diagnosis *requires* impairment in each of the three domains, it is difficult to separate the triad (Happé *et al*., 2006). Similarly, if the sample is too limited in terms of the range of autistic symptoms, the domain components within the sample could be amplified (Constantino *et al.,* 2004). However, as none of the models were a good fit, this seems unlikely. Also, diagnoses of AS or HFA still represent a wide range of severity of autistic symptoms.

4.4.3 Goodness-of-fit statistics

There are questions around the reliability of the statistical tests used to reject or accept the hypotheses in CFA. There are a number of goodness-of-fit tests, and like most statistical tools, all have weaknesses, so need to be treated with caution (Kline, 1994). It has been repeatedly stressed that goodness-of-fit indices should be used as 'rules of thumb' rather than golden rules to follow. Unfortunately, however, it is not meaningful to compare models that do not reach these rules of thumb, which limited the available comparison of results.

4.4.4 The AAA and Procedural Difficulties in Diagnosis

A proportion of the data was archival, so the reliability and validity of the data is dependent on the individuals responsible for assessment. Exact diagnostic method depended on the training of the professional who picked up the case, and apart from a case discussion meeting, there was no inter-rater reliability to ensure agreement surrounding diagnosis. One of the common assessment tools across all clinicians was the use of the AAA, and although not dependant on it, it is likely that diagnosis was influenced by the outcome of the AAA.

In addition, the AQ and EQ are designed to be self-rating measures, but clinicians differed in whether they went through each questionnaire with the client, or asked them to bring them completed to their appointment. Scales based on self-reports have inherent limitations; a client may not understand a question, and so may give a misleading answer whilst trying to answer to the best of their ability (Yirmiya & Charman, 2010). Having a clinician go through the questionnaire to clarify any possible misunderstandings can be clinically helpful, but is time consuming. Also, although self-reported information is clinically important, it may be subject to reporting biases (Yirmiya & Charman, 2010). Individuals may have not wished to 'admit' particular difficulties or give responses that differ from the perceived norm, or perhaps have the insight to recognise these. For instance, there are some items that could be particularly emotive, (e.g. EQ32 *'Seeing people cry doesn't really upset me'*), which, whether it is true or not for the individual, could be difficult to admit. Other items could be difficult to interpret (e.g. AQ1 '*I prefer to do things with others rather than on my own').* The 'prefer' aspect of these types of questions could perhaps make them difficult to answer as they cannot capture the 'weighing up' of many individuals with AS/HFA who may *want* social relationships and *want* to have company, but find it inherently difficult.

4.5 Future research

4.5.1 Further analysis of the validity of the AAA.

Within this clinical sample, CFA did not provide evidence for the four factor structure proposed by the authors of the AAA (Baron Cohen *et al.,* 2005), or any of the other models tested. In order to further explore this, an exploratory factor analysis of the AAA could be completed to examine the factor structure within this set of clinical data, and compared to that proposed by the authors (Baron Cohen *et al*., 2005). It could also be interesting to examine the factor structure within different populations, such as those referred for assessment who did not then go on to meet criteria, or revert to student samples that have been used in many of the AQ validation studies.

Further validation of the AAA could include an independent measure to ensure that the AAA actually measures the ASD phenotype as it aims to. Unfortunately no such 'quality check' was possible within this sample as no other scale was used in the clinical practice where the data were collected. Assessment of AS, particularly in adults, is a relatively new endeavour and as such there is no 'gold standard' procedure (Stoesz *et al.,* 2011).

In hindsight, as this study represents (to the best of the author's knowledge) the first analysis of the structure of the AAA, it may have been more appropriate to ensure the validation of the scale before considering the wider question regarding the structure of autism. Results of the analysis highlight some question of content validity, and as discussed there is no evidence of the four factor structure proposed by the authors (Baron-Cohen *et al*., 2005). It could also be appropriate to establish measurement invariance (the 'unbiasedness' of items) to ensure differences in responses are not due to irrelevant characteristics associated with membership of particular groups (e.g. sex, diagnosis of HFA or AS; Wicherts & Dolan, 2010).

4.5.2 Sex differences

ASD occurs four times more often in males than females (Belfer, 2008), but gender differences in the expression of ASD can also lead to misdiagnosis or under diagnosis in females (Lemon *et al.*, 2011). A future research direction could be to look at differences in factor structure between males and females diagnosed with ASD, as this could be particularly helpful clinically in diagnosis. Females with ASD may be able to 'camouflage' their symptoms by having greater communicative and social abilities (McLennan *et al.,* 1993). It had been hoped that this second level of analysis could be implemented within this thesis, but single group models that fit well are critical in estimating multiple-group models (Tabachnick & Fidell, 2007). Also, in order to evaluate the internal structure and reliability for each gender separately a sample of 100 is needed (Gomez-Pena *et al*., 2011). This could be pursued as future research.

4.6 Clinical and Ethical Implications

4.6.1 The dyad vs. the triad

Previous research reviewed in the systematic review suggested that social and communication impairments should be treated as a single symptom domain. Although the high correlations between social and communication factors are interesting, none of the research hypotheses were supported, and the data could not provide support for any of the projected theoretical models.

4.6.2 The Adult Asperger Assessment.

To the best of the author's knowledge, there has been no empirical testing to assess the construct or criterion validity of the AAA. Only face validity was considered, as items were designed to correspond to specific DSM-IV criterion (Baron-Cohen *et al*., 2005). Within this clinical sample, bearing in mind the limitations of the study, CFA did not provide support for the four factor structure

proposed by the authors of the AAA (Baron Cohen *et al.,* 2005), or any of the other models tested in the other hypotheses. There may be potential difficulties in using a diagnostic tool that does not appear to have a robust underlying structure that corresponds to theoretical models on which it is based.

However, as described in the methodology section 2.4, the proposed four factor structure of the AAA (and the 72 items used as variables within this structure) is just one aspect of the tool. The AAA also provides total scores for both the EQ and AQ that can be compared to clinical cut-offs, that were not examined within this study. The proposed structure also provides a framework for a qualitative interview, and for a clinician with the relevant expertise it seems likely that this is the most important part of the diagnostic process.

4.6.3 Structure of ASD: Dimensionality vs. Discrete disorder

Traditionally, in line with other psychiatric diagnoses, ASD has been considered a 'disease entity' (Rutter, 1978). Thus historically the symptoms of ASD have been presumed to arise from shared underlying abnormality (Mandy & Skuse, 2008). However, although currently all three domains have been required for a diagnosis to be made, the association between them has not been clear. Factor analytic studies have attempted to inform this, by examining whether social, communication and RIBA elements of ASD co-vary. If they do, they should not show up as different factors, as individuals who score highly on social items would be expected to score highly on communication and RIBA items, and vice versa. However if they are not correlated, analysis should result in distinct factors. The factor analytic evidence reviewed in the systematic review (Kuenssberg *et al.,* 2011) could be interpreted to lend some support to the notion that there are two separate dimensions in ASD; social-communication impairments and RIBA (or 'non-social' impairments). It is still unclear whether or not these two domains share the same aetiology.

Some research literature reflects the move towards a dimensional conceptualisation of ASD, with these two domains having different roots and varying developmental trajectories (Happé *et al.,* 2006). It has been proposed that rather being part of a discrete disorder, the characteristics associated with ASD may be a common end state of different aetiological pathways (Moss & Howlin, 2009). For instance, there is an association between ASD and Phenylketonuria (PKU), a genetic disorder associated with deficits in protein metabolism. In late diagnosis, high levels of protein in the diet can often result in ASD symptomatology (Baieli *et al.,* 2003), and comparison of cognitive profiles of individuals with autism and poorly controlled PKU has indicated significant overlap (Dennis *et al*., 1999). Thus, it could be concluded that toxic levels of phenylalanine hydroxylase play a significant role in the development of ASD symptomatology. Of course, this is unlikely to be a common underlying factor in the wider ASD population (Moss & Howlin, 2009). Similarly, in genetic syndromes such as Angelman syndrome, Down syndrome and Tuberous Sclerosis, where the overlap with ASD has been considered to be robust, there is often a difference in phenomenology (Moss & Howlin, 2009). For instance, many individuals with Rett syndrome show an atypical profile of autistic characteristics that often improve with age (Nomura & Segawa, 2005). This is despite the fact that the overlap between Rett syndrome and ASD has been considered so robust that Rett Syndrome is currently classified as a PDD (Moss & Howlin, 2009). The fact that so many different syndromes are associated with the triad of impairments raises the issue of how unique they are to ASD, and questions the boundaries of the diagnosis. It seems unlikely there will be a single shared underlying aetiological pathway, or a single cause (Happé *et al*., 2006; Moss & Howlin, 2009).

It may be that level of functioning mitigates the association of social and non-social impairments in ASD. Wing and Gould (1979) conducted the first study to "assess the prevalence and distribution of the three types of abnormalities, and whether they tend[ed] to occur together" (p13). They found a 'marked tendency' for the association. However, there was a bias against individuals with IQs within the normal range. This association was not replicated by Ronald *et al.* (2005; 2006), who

used a community sample to challenge the notion that social and non-social impairments cluster together and share an aetiology. This raises the questions of whether there is a weaker relationship between social-communication and non-social impairments in high functioning ASD populations (Mandy & Skuse, 2008). This thesis focused on such a population and noted a lower correlation between social and non-social factors, even though it may have been expected that any association would be amplified within a clinical sample who all met the diagnostic criteria for an ASD. Many questions remain; it may be that there are different developmental trajectories for different subtypes of ASD, and the association of domains depends on each subtype. This would still raise doubts as to the discrete nature of ASD.

Much of the literature on ASD does not focus on the population of individuals who have social and communication difficulties indicative of ASD without clinically significant levels of RIBA. This population have been described as representing a further anomaly within the current conceptualisation of ASD (Mandy & Skuse, 2008). These children are diagnosed with PDD-NOS (DSM-IV-TR; APA, 2000) or atypical autism (ICD-10; WHO, 1992). A categorical approach can be really helpful for some clients, in being given a diagnosis with a shorthand explanation of their difficulties (Berney, 2004). It may be less helpful if ASD is conceptualised as a dimensional disorder, if individuals share the same diagnosis but find they do not share the same difficulties. In addition, a 'present/absent' classification may not help to capture the functional impact of the individual's environment, or possible temporal trajectories of development. For instance, an individual may have relatively little difficulty within the structured and contained setting of primary school, but struggle more with the "secondary school confusion" of adolescence (Berney, 2004).

A diagnosis within the field of Clinical Psychology should represent a working hypothesis, and be based on clinical judgment rather than set algorithms. An individualised formulation will always be more functionally helpful within this field than a diagnosis alone. This has been recognised by the British Psychological Society (BPS) in their consultation response to the DSM-V (APA, 2011). Although not disagreeing with the need for a diagnosis relating to ASD, they highlight

"*Alternatives to diagnostic frameworks such as case formulations (whether from a single theoretical perspective or more integrative) exist,* [and] *should be preferred"* (BPS, 2011, p.2). However, diagnosis remains the gateway to services and resources, including financial support, so it is important that diagnostic criteria are clarified to represent the true reflection of the patterns of difficulties that exist. Mandy and Skuse (2008) propose a spectrum of positions clinicians can consider in conceptualising the structure of autism. The traditionalist position; where social and non-social impairments in ASD are highly correlated, with RIBA being universal within this population. Or, a move towards the revisionist position, which argues that there is no meaningful association between social impairments and RIBA. Each position clearly has implications for future research, particularly attempts to characterise any genetic associations, adding to the debate on the conceptualisation of ASD.

5 CONCLUSIONS

The triad of impairments is based more on clinical judgement than empirical evidence, and has been under scrutiny since its inception (Lecavalier *et al*., 2009). As described in the systematic review, the difficulties associated with the current classification system have led researchers to explore empirical alternatives with multivariate statistical programmes such as factor analysis. Although these have suggested a trend towards a dyad model, with one social behaviour factor incorporating social and communication impairments, and one non-social RIBA factor, they have generally been inconclusive. These studies, including this thesis, have yielded different solutions that are not entirely consistent with the behavioural domains of ASD as defined by current classification systems.

The proposal of 'Autistic Disorder' in the DSM-V (APA, 2010) suggests that social and communication behaviours are inseparable, and more accurately considered as a single set of symptoms with contextual and environmental specificities. Although not supporting any of the proposed hypotheses, confirmatory factor analysis did highlight that social and communication domains within the AAA are very highly correlated. A non-social factor was also suggested, but more research is required on the scales used before any firm conclusions can be drawn.

Even if non-refutable evidence was found indicating the triad of impairments does not accurately describe the structure of autism, it has played a hugely important role in providing an easily recognizable and classifiable structure to facilitate diagnosis. Although helpful in raising awareness, a great deal of subsequent research and clinical practice has been based on these assumptions. Thus, attempting to clarify the association between domains of impairment in ASD is extremely important and useful in clinical and academic terms, and also timely, given the proposed changes to DSM-V.

6 JOURNAL ARTICLE

6.1 Chapter Summary

This journal article has been published by the journal *Research in Developmental Disabilities* (Kuenssberg & McKenzie, 2011). Guidelines for authors from this journal can be found in Appendix 1. The article is displayed in the format used for submission, although figures and tables are embedded within the text. As dictated within author guidelines, the systematic review follows APA guidelines, as opposed to BPS guidelines.

Confirmatory Factor Analysis of the Adult Asperger Assessment: The association of symptom domains within a clinical population.

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Abstract

Autism Spectrum Disorder (ASD) is a behaviourally defined disorder characterised by impairments in three domains of social interaction, communication, and repetitive, stereotyped behaviours and activities. Proposed changes to diagnostic criteria suggest that the diagnostic triad may no longer fit as the best way to conceptualise ASD, and that social and communication impairments should be considered as a single domain. The aim of this study was to examine the structure of symptom domains within the *Adult Asperger Assessment* (*AAA*; Baron-Cohen, Wheelwright, Robinson, & Woodbury-Smith, 2005), a diagnostic tool for high functioning adults. As theoretical models already exist, confirmatory factor analysis was used to examine data from a clinical population of adults (n = 153) diagnosed with Asperger Syndrome (AS) and High Functioning Autism (HFA). Confirmatory factor analysis was used to fit different models based on the structure proposed by the authors of the *AAA*, the traditional triad and the newly proposed diagnostic dyad. Analysis suggested that none of the tested models were a good fit on the *AAA* dataset. However, it did highlight very high correlations between social and communication factors ($r > 0.9$) within unmodified models. The results of the analysis provide tentative support for the move towards considering ASD as a dyad of 'social-communication' impairments and repetitive/restricted interests behaviours and activities, rather than the traditional triad.

1. Introduction

Autism Spectrum Disorders (ASD: also known as Pervasive Developmental Disorders [PDD]) are characterized by impairments in the three domains of social interaction, communication, and repetitive/restricted interests, behaviours and activities (RIBA) in current diagnostic manuals (DSM-IV-TR; American Psychiatric Association [APA], 2000; ICD-10; World Health Organisation [WHO], 1992). In line with most other psychiatric diagnoses, ASD has traditionally been conceptualised as a discrete category, but a consensus is emerging that it is in fact a dimensional disorder reflecting developmental difficulties at the extreme end of a continuum (Mandy & Skuse, 2008). Evidence for this dimensionality has been provided by the broader autistic phenotype in siblings of those with ASD (e.g. Piven, Jacobi, Childress, & Arndt, 1997) and by studies showing that ASD traits are continuously distributed in large general population studies (Constantino & Todd, 2003; Posserud, Lundervold, & Gillberg, 2006). However, the nature of the dimensionality of ASD, and particularly the association between the three domains of impairment, continues to elicit debate.

Although not due for publication until 2013, the fifth edition of the diagnostic and statistical manual (DSM-V) acknowledges the questions surrounding the association of symptom domains as it proposes ASD move to 'Autistic Disorder' (APA, 2010). The three symptom domains are merged into two: 'social-communication' deficits as a single domain, and fixated interests and repetitive behaviours (or RIBA) as a second. It also proposes that Asperger syndrome (AS) be subsumed into Autistic Disorder (APA, 2010). Thus, diagnostic criteria for AS would rely on this proposed 'dyad' of domains. Currently, boundaries between the subtypes of ASD remain unclear (in particular autism, high functioning autism [HFA], AS and Pervasive Developmental Disorder – Not Otherwise Specified [PDD-NOS]). Most researchers consider them as a continuum of the same disorder, with varying degrees of symptom severity and intellectual functioning (Freitag, 2007). They are currently conceptualised to share the triad of impairments, although for a diagnosis of AS, no impairment in communication or language delay is evident.

Confusion arises around communication difficulties and AS, as authors have highlighted clinical difficulties in prosody (Paul, Augustyn, Klin, & Volkmar, 2005) and pragmatic impairments (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999; Landa & Goldberg, 2005). These are not currently required for diagnosis, and are not stated in DSM-V.

The proposed changes to diagnostic criteria for Autistic Disorder suggest a change in the structure associated with ASD. The traditional triad of impairments becomes a dyad, with social and communication impairments being considered as a single domain. Historically, in line with other psychiatric diagnoses, ASD has been considered a 'disease entity' (Rutter, 1978). Within this framework, the symptoms of social impairments, communication impairments and RIBA are presumed to be associated, as they would arise from the shared underlying abnormality (Mandy & Skuse, 2008). The move away from ASD as a discrete category towards a dimensional conceptualisation has reignited debate about the nature of the association between domains of impairment. Although currently all three domains are required for a diagnosis to be made, the association between them remains unclear.

One method authors have used to consider the association between symptoms and the structure of autism is by using factor analysis. Factor analytic techniques are used to pull out underlying structures (known as factors or components) by identifying which items co-vary (Kline, 1994). As such, factor analysis can examine whether or not the social, communication and RIBA domains of ASD co-vary and correlate. If they do, they should not show up as different factors, as individuals who score highly on social items would be expected to score highly on communication and RIBA items, and vice versa. However if they are not correlated, analysis should result in distinct factors. A recent review of the literature (Kuenssberg, McKenzie, & Jones, *in press*) highlighted that despite three decades of exploration there is still no clear answer about the triad's empirical relevance. The majority of analyses resulted in authors recommending a move towards conceptualising social deficits and communication deficits as being a shared social-communication factor, in line with proposed DSM-V amendments (e.g. Frazier, Youngstrom, Kubu, Sinclair, & Rezai,

2008; Georgiades et al., 2007; Kamp-Becker, Ghahreman, Smidt, & Remschmidt, 2009; Snow, Lecavalier, & Houts, 2009; van Lang et al., 2006).

Despite ongoing debate about the structure of ASD, awareness has grown exponentially after Rutter's influential review and generation of the 'Rutter criteria' (Rutter, 1978), and the subsequent publication of the DSM-III in 1980 (APA, 1980). Professionals are now alert and informed of the possibility of children with ASD, and as a result there are a growing number of tools targeted for assessment and diagnosis. Currently, the 'gold standard' for assessment in childhood is the *Autism Diagnosis Interview-Revised* (*ADI-R*; Lord, Rutter, & Le Couteur, 1994) and the *Autism Diagnostic Observation Schedule – Generic* (*ADOS-G*; Lord et al., 2000). However, these tools are time consuming to administer, complex, and require expensive training. They are also not age-appropriate for adults born before the ASD watershed of the 1980s (Baron-Cohen, Wheelwright, Robinson, & Woodbury-Smith, 2005). Diagnosis of autism and AS in adulthood can be difficult, as they share many symptoms with other DSM-IV-TR disorders, such as social anxiety disorder, obsessive–compulsive disorder, and schizoaffective disorder (Baron-Cohen & Wheelwright, 2004; Fitzgerald & Corvin, 2001).

One tool designed to diagnose AS in adults is the *Adult Asperger Assessment* (*AAA*; Baron-Cohen et al., 2005). This links two self-report screening instruments, the *Autism-Spectrum Quotient* (*AQ*: Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) and the *Empathy Quotient* (*EQ*: Baron-Cohen & Wheelwright, 2004). The client's response to each item on the *AQ* and *EQ* is entered into the *AAA* spreadsheet, and a macro is run to score the client's response into one of four sections of the *AAA*; (i) qualitative impairments in social skills (Social); (ii) restricted repetitive and stereotyped patterns of behaviour, interest and activities (RIBA); (iii) qualitative impairments in verbal or nonverbal communication (Comm); and (iv) impairments in imagination (Imag). The *AQ* and *EQ* responses form two functions; all the completed items are used to provide an overall score which can be compared to clinical cut-offs (Baron-Cohen et al., 2005), but 72 of the *AQ* and *EQ* items are also used as examples of impairment within each section of the *AAA* (see Table 1, as described in the example *AAA* in Baron-Cohen et al., 2005). This can then be used as the basis of a qualitative interview, and directly compared to DSM-IV criteria.

Table 20: Items of the *AAA* and corresponding section, as described by Baron-Cohen et al., 2005).

Section A 'Qualitative impairment in Social Interaction'	**AQ Items** **1.** I prefer to do things with others rather than on my own **10.** In a social group, I can easily keep track of several different people's conversations* **11.** I find social situations easy* **15.** I find myself drawn more strongly to people than to things **20.** When I'm reading a story, I find it difficult to work out the characters' intentions **22.** I find it hard to make new friends **27.** I find it easy to "read between the lines" when someone is talking to me* **35.** I am often the last to understand the point of a joke **36.** I find it easy to work out what someone is thinking or feeling just by looking at their face* **44** . I enjoy social occasions* **45**. I find it difficult to work out people's intentions.
	EQ Items **8**. I find it hard to know what to do in a situation **11**. It doesn't both me too much if I am late meeting a friend **12**. Friendships and relationships are just too difficult, so I tend not to bother with them. **19.** I can pick up quickly if someone says one thing but means another* **21.** It is hard for me to see why some things upset people so much **22.** I find it easy to put myself in somebody else's shoes* **25.** I am good at predicting how someone will feel* **26.** I am quick to spot when someone in a group is feeling awkward or uncomfortable* **32.** Seeing people cry doesn't really upset me **35.** I don't tend to find social situations confusing* **39.** I am able to make decisions without being influenced by people's feelings* **43.** Friends usually talk to me about their problems as they say that I am very understanding* **44.** I can sense if I am intruding, even if the other person doesn't tell me* **48.** Other people, often say that I am insensitive, though I don't always see why **49.** If I see a stranger in a group, I think that it is up to them to make an effort to join in **50.** I usually stay emotionally detached when watching a film **52.** I can tune into how someone else feels rapidly and intuitively* **55**. I can tell if someone is masking their true emotion* **57.** I don't consciously work out the rules of social situations* **58.** I am good at predicting what someone will do* **59**. I tend to get emotionally involved with a friend's problems*
Section B 'Restricted repetitive and stereotyped patterns of behaviour, interest and activities'	**AQ Items** **2.** I prefer to do things the same way over and over again **4.** I frequently get so strongly absorbed in one thing that I lose sight of other things **5.** I often notice small sounds when others do not **6.** I usually notice car number plates or similar strings of information

	9. I am fascinated by dates **12.** I tend to notice details that others do not **16.** I tend to have very strong interests which I get upset about if I can't pursue **19.** I am fascinated by numbers **23.** I notice patterns in things all the time **25.** It does not upset me if my daily routine is disturbed* **28.** I usually concentrate more on the whole picture, rather than the small details* **30.** I don't usually notice small changes in a situation, or a person's appearance* **41.** I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).
	EQ Items **10.** People often tell me that I went too far in driving my point home in a discussion **60.** I can usually appreciate the other person's viewpoint, even if I don't agree with it*
Section C 'Qualitative impairments in verbal or nonverbal communication'.	**AQ items** **7**. Other people frequently tell me that what I've said is impolite, even though I think it is polite **17.** I enjoy social chit-chat* **26**. I frequently find that I don't know how to keep a conversation going **31**. I know how to tell if someone listening to me is getting bored* **33.** When I talk on the phone, I'm not sure when it's my turn to speak **38**. I am good at social chit-chat* **39.** People often tell me that I keep going on and on about the same thing **48**. I am a good diplomat*
	EQ items **1.** I can easily tell if someone else wants to enter a conversation* **14.** I often find it difficult to judge if something is strongly rude or polite **15**. In a conversation, I tend to focus on my own thoughts rather than on what my listener might be thinking **27.** If I say something that someone else is offended by, I think that that's their problem, not mine **28**. If anyone asked me if I liked their haircut, I would reply truthfully, even if I didn't like it **29.** I can't always see why someone should have felt offended by a remark **34**. I am very blunt, which some people take to be rudeness, even though this is unintentional **37.** When I talk to people, I tend to talk about their experiences rather than my own* **41**. I can easily tell if someone else is interested bored with what I am saying* **46.** People sometimes tell me that I have gone too far with teasing. **54.** I can easily work out what another person might want to talk about*
Section D 'Impairments in imagination'	**AQ Items** **14.** I find making up stories easy* **21.** I don't particularly enjoy reading fiction **24.** I would rather go to the theatre than a museum*

	40. When I was young, I used to enjoy playing games involving pretending with other children* **42**. I find it difficult to imagine what it would be like to be someone else **50**. I find it very easy to play games with children that involve pretending*
	EQ items – nil

For a diagnosis of AS or HFA, individuals need to display symptoms in each of the four sections detailed above. The *AAA* had been designed to be more stringent than DSM-IV criteria, so anyone who meets the *AAA* criteria will also meet DSM-IV criteria (Baron-Cohen et al., 2005). Differential diagnosis between AS and HFA depends on the absence or presence of developmental language delay respectively. The *AAA* includes six items relating to imagination, although the authors acknowledge debate over imagination deficits in AS, and indeed within ASD. Imaginative behaviours include activities ranging from simple pretend play to creative engagement with fictional stories. There is some debate over whether or not the concept of impaired imagination is linked to repetitive behaviour (as described by Wing & Gould, 1979) or communication impairments, as described within classification systems (within the lack of spontaneous make-believe play: APA, 2000). As described, these diagnostic systems provide a separate category for RIBA. However, explorative factor analytic studies have suggested a three way association between repetitive behaviour, imagination and communication (Honey, Leekam, Turner, & McConaghie, 2007).

The purpose of the current Scottish study was to further investigate the association of social, communication and RIBA domains of impairment in AS and HFA by examining the factor structure of the 72 items detailed in table 1 within the *AAA*, within a clinical sample. As theoretical models about the structure of ASD already exist, confirmatory factor analysis was used to assess competing models. These were based on the four factor structure proposed by the authors of the *AAA* (Baron-Cohen et al., 2005), the triad of impairments, or the newly proposed dyad. Due to the debate surrounding the requirements regarding Imagination, this factor will be including systematically with each of the other domains of impairment. (See figure 1 for a brief schematic of the models tested).

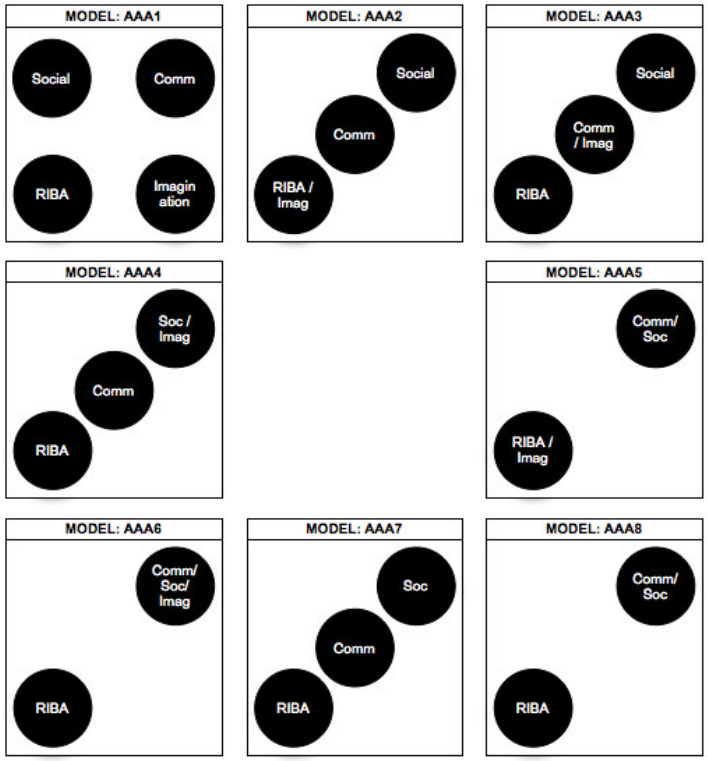

Figure 1. Brief schematic of models fitted to the *AAA* data

2. Method

Ethical approval was received from the local NHS ethics committee and Caldicott Guardians, and the local research department.

2.1 Participants

The Regional ASD Consultancy Service (RASDCS) is a multi-professional service aiming to provide diagnosis and advice to individuals over 18years old in Scotland. The service covers four health boards, with case-holders from each health board working on a good-will basis as part of the local managed care network. Closed files of 140 adults who had attended the regional service or been assessed by its associated staff and who had received a diagnosis of AS/HFA were reviewed. Before referring to RASDCS, local psychologists complete some ASD diagnostic assessments using the same tools as RASDCS. Thirteen extra cases were sourced

from these clinicians to add to the sample. The total sample consisted of 153 adults. Mean age of the sample was 33 years (standard deviation [SD] = 11), with a range of 17–75years. The sample consisted of 110 men and 43 women (male to female sex ratio of 2.6:1). There was no difference between the mean age of males or females ($p > .05$).

2.2 Measures

2.2.1 Adult Asperger Assessment

There have been no large-scale standardisation studies for the *AAA* (Stoesz, Montgomery, Smart, & Hellsten, 2011). The only published study presenting validity evidence for the *AAA* was with a small sample, reported by the authors (Baron-Cohen et al., 2005). There has been no further published empirical evidence of the reliability of the *AAA*. It is reported as having good content validity, in that it appears to be consistent with symptoms and concepts in the literature (Baron Cohen et al., 2005), however, to the best of the authors' knowledge, no further empirical data on the complete *AAA* has been published. The two subscales within the *AAA*, the *AQ* and the *EQ*, have had more empirical assessment. For a review see Stoesz et al. (2011).

Within the *AAA*, the individual's responses can be scored in two ways; 0/1 or 0/1/2 scoring is used to compare with clinical cut-off scores in the *AQ* (Baron-Cohen et al., 2001) and *EQ* (Baron-Cohen & Wheelwright, 2004) respectively; or on a continuous 4 point Likert-scale on the *AQ* (1 = definitely agree, 2 = slightly agree, 3 = slightly disagree, and 4 = definitely disagree) and the *EQ* (1 = strongly agree, 2 = slightly agree, 3 = slightly disagree, and 4 = strongly disagree). Using the continuous Likert-scale retains more information about participants' responses so helpful for factor analysis (Stewart & Austin, 2009). This utilises valuable information about the degree of endorsement for each item (Austin, 2005). Some of the items are reversed, with a 'disagree' response characteristic of autism, so the data was transformed to account for this reverse scoring. These items are marked with an asterisk (*) in Table 1. Within this analysis, higher scores on both the *AQ* and the *EQ* represent a higher autistic phenotype.

2.3 Procedure

All clients were assessed for the presence of AS/HFA according to DSM-IV-TR criteria by experienced clinicians, although the exact procedure varied depending on the clinician's training and case presentation (e.g. assessment by a psychologist might incorporate neuropsychological assessment, assessment by psychiatrists may include assessment of personality disorder or schizotypal psychopathology as differential diagnosis). Accordingly, cases were allocated on an assessment-needs basis. However, every client underwent clinical interview, and wherever possible an informant was sourced for developmental review. This was a semi-structured interview, ideally with a parent, which covered early development in all domains of autism spectrum conditions. This encompassed: birth history, medical history, family history, motor development, play behaviour, social behaviour, communication and other behaviour such as sensory sensitivities from 0-3 years. Each case was discussed at a multidisciplinary clinic before final diagnosis, but assessment was completed by one professional. Although not dependant on *AAA* scores, diagnoses were not independent of assessment, as it was part of the battery used.

2.4 Confirmatory Factor Analysis of the AAA dataset

Confirmatory factor analysis explicitly tests *a priori* hypotheses between observed variables and latent factors. It is the analytic tool of choice for exploring structure when theories already exist, and in developing and refining measurement instruments (Jackson, Gillaspy, & Purs-Stephenson, 2009).

Model AAA1 was a four factor solution as suggested by the authors of the AAA (Baron-Cohen et al., 2005). This model stipulated four separate domains; (i) qualitative impairments in social interaction (Soc); (ii) Restricted, repetitive and stereotyped patterns of behaviour, interests and activities (RIBA); (iii) Qualitative impairments in verbal or non-verbal communication (Comm); and (iv) Impairments in imagination (Imag). Model AAA2 was a three factor 'triad' of impairments as stipulated by current diagnostic criteria, but included imagination as a function of RIBA (RIBA/Imag). Model AAA3 again used the triad, but with imagination as a function of communication (Com/Imag). For completeness, and considering the debate about the proposed overlap between social and communication symptom

domains, Model AAA4 used the diagnostic triad but with imagination as a function of social skills (Soc/Imag). The next two models used a two factor 'dyad' solution as proposed by changes to DSM-V diagnostic criteria, with social and communication impairments as a single symptom domain (Com/Soc). Model AAA5 used this domain along with imagination as a function of RIBA (RIBA/Imag) and Model AAA6 included imagination as a function of this single 'social/communication' factor (Con/Soc/Imag). The final two models excluded imagination from the models completely: Model AAA7 was the DSM-IV-TR described triad, and Model AAA8 the newly proposed DSM-V dyad.

2.5 Goodness –of- fit indices

Jackson et al.'s reporting guidelines checklist (2009) guided the inclusion of multiple fit indices; MLM chi-square (also known as the Sattora-Bentler chi-square), the comparative fit index (CFI; Bentler, 1990), the Tucker-Lewis Index (TLI; Tucker & Lewis, 1973), the root-mean-square error of approximation (RMSEA) and the standardised root mean square residual (SRMR). Cut-off 'rules of thumb' were based on Hu and Bentler (1999). In the case of CFI and TLI, values above .95 indicated a good / acceptable fit; RMSEA of .06 or less; and for the SRMR values of .08 or less were desired.

3. Results

The correlation matrix was checked for multicollinearity and singularity. Given that both Bartlett's and the KMO measure were within reasonably acceptable limits, factor analysis was considered to be an appropriate way to explore the dataset. No outliers were identified.

Skewness and kurtosis z scores were calculated, and it was found that the variables were non-normal in different ways (i.e. some positively and some negatively skewed). A Kolmogorov-Smirnov test suggested that all the items differed significantly from a normal distribution. This was unsurprising given that data

distribution from a clinical population may not be expected to be normal (Tabachnick & Fidell, 2007). As the data did not have a normal distribution, a non-parametric test MPlus v5.21 (Muthén & Muthén, 1998-2011) was used to run the confirmatory factor analysis on the correlation matrix. In models with data which are considered multivariate, maximum likelihood mean (with standard errors and a mean-adjusted chi-square test statistic robust to non-normality; MLM) is typically used to estimate the models. The MLM chi-square test statistic is also referred to as the Satorra-Bentler chi-square. MLM uses a list-wise procedure to deal with missing data. This reduced the dataset (n = 110). This means there is a likelihood that there are not enough participants for the number of items within the questionnaire, and results need to be treated with caution. However, the dataset is still over 100, and importantly there were more subjects than factors (Kline, 1994).

3.1 CFA findings

As can be seen from table 2, none of the models had a good or acceptable fit to the data (CFI and TFI < .95, RMSEA > .6, SRMR > .08). The best fitting model, based on the best fitting CFI although still poor, is AAA7, the traditional DSM-IV-TR triad model of social skills, communication and RIBA, that ignores *AAA* items that relate to the Imagination factor. The next closest fitting model was the proposed dyad of Social and communication impairments as a single factor, and RIBA as a separate 'non-social' factor, again ignoring the *AAA* items that relate to the Imagination factor. However, as the meaningfulness of any difference in fit indices (e.g. a difference in RMSEA values) can't be determined, small difference in fit indices should not be over-interpreted.

Table 21. Indices of fit for the CFA models

	MLM χ^2	CFI > .95	TLI > .95	RMSEA < .06	SRMR < .08
AAA1	4730.36	.415	.397	.091	.117
AAA2	4827.22	.391	.372	.093	.118
AAA3	4753.88	.410	.392	.091	.116
AAA4	4752.81	.410	.392	.091	.116
AAA5	4840.44	.388	.370	.093	.118
AAA6	4765.65	.407	.390	.091	.117
AAA7	4071.92	.428	.409	.093	.118
AAA8	4087.74	.424	.406	.093	.119

As none of the models provided an acceptable fit, factor loadings are not reported, but are available on request from the first author. In each of the models tested on *AAA* data, social and communication factors correlated highly ($r > .9$, $p < .0001$). Factor correlations within each model fitted to *AAA* data are shown in Table 3.

This could suggest that it may not be plausible to separate the communication and social factors in each of the models fitted to the data. There was also a high correlation between the Communication factors and Imagination factors in the four factor model ($r = .686$, $p < .0001$), and in the three factor model when imagination items and RIBA items were fitted as a single domain ($r = .708$, $p < .0001$). There was a lower correlation between the Communication factors and RIBA when Imagination items were not grouped together ($r = .503$, $p < .0001$).

Table 22: Factor Correlations within each Model fitted to *AAA* data

Model	Correlating factor	With…	*r*	$p \leq$
AAA1	RIBA	SOCIAL	.271	.001
	COMM	SOCIAL	**.958**	.001
		RIBA	.462	.001
	IMAG	SOCIAL	**.705**	.001
		RIBA	.210	.001
		COMM	.686	.001
AAA2	RIBA/IMAG	SOCIAL	.530	.001
	COMM	SOCIAL	**.954**	.001
		RIBA/IMAG	**.708**	.001
AAA3	RIBA	SOCIAL	.263	.001
	COMM/IMAG	SOCIAL	**.961**	.001
		RIBA	.429	.001
AAA4	RIBA	SOC/IMAG	.277	.001
	COMM	SOC/IMAG	**.960**	.001
		RIBA	.465	.001
AAA5	RIBA/IMAG	COMM/SOC	.612	.001
AAA6	RIBA	COMM/SOC/IMAG	.316	.001
AAA7	RIBA	SOCIAL	.295	.001
	COMM	SOCIAL	**.947**	.001
		RIBA	.503	.001
AAA8	RIBA	COMM/SOC	.340	.001

* correlations above .7 are highlighted in bold

4. Discussion

A confirmatory factor analysis is a means of testing how the data fit models proposed by theory. The factor structure is suggested *a priori* either by previous analyses and theoretical constructs. ASD has been proposed to be a triad of impairments, with three separate domains of social skills, communication and RIBA. However, proposed changes to the DSM-V diagnostic criteria for autistic disorder suggest a dyad of impairments, with social and communication as a single symptom domain, and RIBA as a separate 'non-social' domain. These models, as well as a four factor model proposed by the authors of the *AAA* (Baron-Cohen et al., 2005) were fitted to data from a clinical population for adult diagnosed with AS or HFA. Because the *AAA* also has items relating to 'Imagination', different models were also tested to see if fit was improved incorporating these items into each domain.

None of the models showed a good fit to the *AAA* data, and none met the goodness-of-fit rules of thumb of CFI > .95, TLI > .95, RMSEA < .06 or SRMR < .08. The best fitting models were those that excluded all of the imagination items from the analysis. The traditional triad of social skills, communication and RIBA, and the proposed dyad of a joined social-communication factor and RIBA were the best fitting models, but as neither model was significant it is not meaningful to compare the fit between the two.

However, examination of the correlations between factors suggested potential difficulties in considering social and communication factors as separate domains. In all the *AAA* models fitted to the data, communication and social factors were very highly correlated ($r > .9$, $p < .001$). This suggests significant overlap between the variance explained by each factor. The low correlations between social and RIBA factors could also suggest strength in the dyad structure being proposed.

4.1 Limitations

Results of this study need to be treated with caution due to methodological difficulties, particularly regarding the limited sample size. There are no clear guidelines on the size of a sample suitable for factor analysis, although the general rule of thumb is the more data the better (Kline, 1994). Other recommendations vary from $N - n - 1 \geq 50$ (where N = number of participants and n = number of variables) (Lawley & Maxwell, 1971), N at least 100 (Gorsuch, 1983), to a rating scale where 100 = poor, 200 = fair, 300 = good, 500= very good, 1000 or more = excellent (Comrey & Lee, 1992). This study initially met the $N - n - 1 \geq 50$ rule recommended by Lawley and Maxwell (1971), but was reduced to 'N at least 100' (Gorsuch, 1983) due to missing data.

Also, uncertainly still exists as to whether or not AS differs meaningfully from HFA (Rutter, 2011). At the moment they are generally considered to be distinguishable by the presence of an early delay in language acquisition (HFA) or not (AS). Within this analysis, there was no consistent clarification as to whether each client had been diagnosed with AS or HFA, so the sample was treated a single subgroup. This was deemed appropriate as they are treated as a single group

clinically, so were examined together within the analysis, but it could be that in the future if differences are delineated, the factor structure could differ for each sub-type.

4.2 Clinical Implications

As always, these results can only be generalised to the sample that was used to estimate and test the model (Tabachnick & Fidell, 2007). However, the reported high correlation and potential overlap between social and communication factors seems to make sense clinically: the qualitative impairments in social interaction can result in difficulty interpreting communication, and impaired communication in ASD exists across a broad spectrum affecting both verbal and nonverbal impairments (Cashin & Barker, 2009). Thus, particularly nonverbal deficits such as difficulties with facial expression and gesture are clearly going to have social ramifications. If clinicians are currently using diagnostic tools that have been designed to reflect the triad of impairments with social and communication impairments being treated as separate factors, it could be that the same difficulty is, in effect, 'counted twice' within diagnostic procedures.

Although on one level the results of the analysis could be considered further evidence of the potential diagnostic 'overweighting' in treating social and communication domains as two separate factors, it does seem likely that the *AAA* requires further assessment as a diagnostic tool. This study has not found evidence for the four factor structure proposed by the authors, Baron-Cohen et al. (2005). There may be potential difficulties in using a diagnostic tool that does not appear to have a robust underlying structure that corresponds to theoretical models on which it is based. Unfortunately, all the results relating to the *AAA* need to be treated with caution due to the small sample size.

As CFA did not provide evidence of a good fit for any of the models suggested, an exploratory factor analysis of the *AAA* could be completed to examine the factor structure within the clinical data, and compare it to the four factor structure proposed by the authors (Baron Cohen et al., 2005). The proposed four factor structure forms the framework for quantitative 'tallying' of symptoms against DSM-IV criteria. It is not clear whether these items within the *AAA* correspond to their stipulated areas, and this requires more examination. However, the 72 items that are

the variables for the proposed structure of the *AAA* is just one aspect of the tool: the *AAA* also provides cut-off scores for both the *EQ* and *AQ* that were not examined within this study, and the proposed structure provides a framework for a qualitative interview. Clinically, it seems likely that the latter is the most important part of the diagnostic process.

Further validation of the *AAA* could include a second measure to ensure that it actually measures the ASD phenotype as it aims to. Unfortunately no such 'quality check' was possible within this sample as no other scale was used in the clinical practice where the data were collected. Validation of the *AAA* could include establishing measurement invariance (the 'unbiasedness' of items) to ensure differences in responses are not due to irrelevant characteristics associated with membership of particular groups (e.g. sex, diagnosis of HFA or AS; Wicherts & Dolan, 2010). Assessment of AS, particularly in adults, is a relatively new endeavour and as such there is no 'gold standard' procedure (Stoesz et al., 2011).

5. Conclusion

A review of previous research suggested that social and communication impairments in ASD should be treated as a single symptom domain (Kuenssberg, McKenzie & Jones, 2011). This would be in line with proposed changes to DSM-V criteria for Autistic Disorder. Models based on the DSM-IV triad, DSM-V dyad and a four factor model proposed by the *AAA* authors (Baron-Cohen et al., 2005) were fitted to data from a high functioning group of adults diagnosed with AS or HFA. None of the models showed a good fit, but high correlations between social and communication factors could support a move away from the diagnostic triad of impairments. Even within the limitations of this study, this provides further support for the dyad of impairments proposed by DSM-V. This study is the first to consider the structure of ASD by using *AAA* data from a high functioning clinical population. Even with the limitations of sample size, it has highlighted that more research is required both on this diagnostic tool, but also on the conceptualisation of ASD with this population.

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8 APPENDICES

Appendix 1: RIDD: Guidelines for Authors

ELSEVIER

RESEARCH IN DEVELOPMENTAL DISABILITIES

AUTHOR INFORMATION PACK

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DESCRIPTION

Research In Developmental Disabilities is aimed at publishing original research of an interdisciplinary nature that has a direct bearing on the remediation of problems associated with developmental disabilities. Manuscripts will be solicited throughout the world. Articles will be primarily empirical studies, although an occasional position paper or review will be accepted. The aim of the journal will be to publish articles on all aspects of research with the developmentally disabled, with any methodologically sound approach being acceptable. A list of topics areas that is illustrative but not inclusive is applied behavior analysis, pharmacotherapy, traditional assessment, behavioral assessment, speech training and occupational therapy. Our aim is to publish the best available and most current research possible.

AUDIENCE

Psychologists, Social Workers, Rehabilitation Specialists and Sociologists

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Appendix 2: AAA, AQ and AQ-S Structure Descriptions.

Table 2. Description of the structure of the AAA: AQ and EQ items in corresponding sections (Baron Cohen *et al*., 2005)

Section	Items
Qualitative impairment in Social Interaction	*AQ items* **1.** I prefer to do things with others rather than on my own* **10.** In a social group, I can easily keep track of several different people's conversations* **11.** I find social situations easy* **15.** I find myself drawn more strongly to people than to things* **20.** When I'm reading a story, I find it difficult to work out the characters' intentions **22.** I find it hard to make new friends **27.** I find it easy to "read between the lines" when someone is talking to me* **35.** I am often the last to understand the point of a joke **36.** I find it easy to work out what someone is thinking or feeling just by looking at their face* **44.** I enjoy social occasions* **45.** I find it difficult to work out people's intentions.
	EQ items **8**. I find it hard to know what to do in a situation **11**. It doesn't both me too much if I am late meeting a friend **12**. Friendships and relationships are just too difficult, so I tend not to bother with them. **19**. I can pick up quickly if someone says one thing but means another* **21**. It is hard for me to see why some things upset people so much **22**. I find it easy to put myself in somebody else's shoes* **25**. I am good at predicting how someone will feel* **26**. I am quick to spot when someone in a group is feeling awkward or uncomfortable* **32**. Seeing people cry doesn't really upset me **35**. I don't tend to find social situations confusing* **39**. I am able to make decisions without being influenced by people's feelings* **43**. Friends usually talk to me about their problems as they say that I am very understanding* **44.** I can sense if I am intruding, even if the other person doesn't tell me* **48**. Other people, often say that I am insensitive, though I don't always see why **49**. If I see a stranger in a group, I think that it is up to them to make an effort to join in **50**. I usually stay emotionally detached when watching a film **52.** I can tune into how someone else feels rapidly and intuitively* **55**. I can tell if someone is masking their true emotion* **57**. I don't consciously work out the rules of social situations* **58**. I am good at predicting what someone will do*

	59. I tend to get emotionally involved with a friend's problems*
Restricted repetitive and stereotyped patterns of behaviour, interest and activities	*AQ items* **2.** I prefer to do things the same way over and over again **4.** I frequently get so strongly absorbed in one thing that I lose sight of other things **5.** I often notice small sounds when others do not **6.** I usually notice car number plates or similar strings of information **9.** I am fascinated by dates **12.** I tend to notice details that others do not **16.** I tend to have very strong interests which I get upset about if I can't pursue **19.** I am fascinated by numbers **23.** I notice patterns in things all the time **25.** It does not upset me if my daily routine is disturbed* **28.** I usually concentrate more on the whole picture, rather than the small details* **30.** I don't usually notice small changes in a situation, or a person's appearance* **41.** I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).
	EQ items **10.** People often tell me that I went too far in driving my point home in a discussion **60**. I can usually appreciate the other person's viewpoint, even if I don't agree with it*
Qualitative impairments in verbal or nonverbal communication.	*AQ items* **7.** Other people frequently tell me that what I've said is impolite, even though I think it is polite **17.** I enjoy social chit-chat* **26.** I frequently find that I don't know how to keep a conversation going **31.** I know how to tell if someone listening to me is getting bored* **33.** When I talk on the phone, I'm not sure when it's my turn to speak **38.** I am good at social chit-chat* **39.** People often tell me that I keep going on and on about the same thing **48.** I am a good diplomat*
	EQ items **1.** I can easily tell if someone else wants to enter a conversation* **14**. I often find it difficult to judge if something is strongly rude or polite **15.** In a conversation, I tend to focus on my own thoughts rather than on what my listener might be thinking **27.** If I say something that someone else is offended by, I think that that's their problem, not mine **28.** If anyone asked me if I liked their haircut, I would reply truthfully, even if I didn't like it

	29. I can't always see why someone should have felt offended by a remark **34.** I am very blunt, which some people take to be rudeness, even though this is unintentional **37.** When I talk to people, I tend to talk about their experiences rather than my own* **41.** I can easily tell if someone else is interested bored with what I am saying* **46.** People sometimes tell me that I have gone too far with teasing. **54.** I can easily work out what another person might want to talk about*
Impairments in imagination	*AQ items* **14.** I find making up stories easy* **21.** I don't particularly enjoy reading fiction **24.** I would rather go to the theatre than a museum* **40.** When I was young, I used to enjoy playing games involving pretending with other children* **42.** I find it difficult to imagine what it would be like to be someone else **50.** I find it very easy to play games with children that involve pretending*
	EQ items **nil**

* Asterisked items represent reverse scoring

Table 3. Description of the structure of the AQ: Items and corresponding sections (Baron-Cohen *et al.* 2001)

Factor	Items
Social Skill	**1.** I prefer to do things with others rather than on my own* **11**. I find social situations easy* **13**. I would rather go to a library than a party. **15**. I tend to find myself drawn more strongly to people than to things* **22**. I find it hard to make new friends. **36**. I find it easy to work out what someone is thinking or feeling just by looking at their face.* **44**. I enjoy social occasions* **45**. I find it difficult to work out people's intentions **47**. I enjoy meeting new people* **48.** I am a good diplomat*
Attention Switching	**2**. I prefer to do things the same way over and over again **4.** I frequently get so strongly absorbed in one thing that I lose sight of other things **10**. In a social group, I can easily keep track of several different people's conversations* **16.** I tend to have very strong interests which I get upset about if I can't pursue. **25**. It does not disturb me if my daily routine is disturbed* **32**. I find it easy to do more than one thing at once* **34**. I enjoy doing things spontaneously* **37**. If there is an interruption, I can switch back to what I was doing very quickly.* **43.** I like to plan any activities I participate in carefully. **46**. New situations make me anxious
Attention to Detail	**5.** I often notice small sounds when others do not **6**. I usually notice car number plates or similar strings of information **9**. I am fascinated by dates **12**. I tend to notice details that others do not. **19**. I am fascinated by numbers. **23**. I notice patterns in things all the time. **28.** I usually concentrate more on the whole picture rather than the small details* **29.** I am not very good at remembering phone numbers* **30.** I don't usually notice small changes in a situation or a person's appearance* **49.** I am not very good at remembering people's dates of birth*
Communication	**7.** Other people frequently tell me that what I've said is impolite, even though I think it is polite **17.** I enjoy social chit-chat* **18.** When I talk, it isn't always easy for others to get a work in edgeways **26.** I frequently find that I don't know how to keep a conversation going **27.** I find it easy to 'read between the lines' when someone is talking

	to me* **31.** I know how to tell if someone listening to me is getting bored* **33.** When I talk on the phone, I'm not sure when it's my turn to speak **35.** I am often last to understand the point of a joke. **38.** I am good at social chit-chat* **39.** People often tell me that I keep going on and on about the same thing.
Imagination	**3**.If I try to imagine something I find it very easy to create a picture in my mind* **8**. When I am reading a story, I can easily imagine what the characters might look like* **14**. I find making up stories easy* **20**. When I am reading a story, I find it difficult to work out the characters' intentions. **21.** I don't particularly enjoy reading fiction **24.** I would rather go to the theatre than a museum. **40.** When I was young, I used to enjoy playing games involving pretending with other children* **41**. I like to collect information about categories of things. **42**. I find it difficult to imagine what it would be like to be someone else. **50**. I find it very easy to play games with children that involve pretending.*

*Asterisked items represent reverse scoring

Table 4: Description of the factor structure of the AQ as proposed by Austin (2005) and Hurst *et al.,* (2007).

Factor	Items
Social Skill	**11**. I find social situations easy* **13**. I would rather go to a library than a party. **15**. I tend to find myself drawn more strongly to people than to things* ***17.*** *I enjoy social chit-chat**(**moved from communication)* **22**. I find it hard to make new friends. ***26.*** *I frequently find that I don't know how to keep a conversation going* ***(moved from communication)*** ***34****. I enjoy doing things spontaneously****(moved from communication)*** ***38.*** *I am good at social chit-chat**(**moved from communication)*** ***40.*** *When I was young, I used to enjoy playing games involving pretending with other children** ***(moved from imagination)*** **44**. I enjoy social occasions* **47**. I enjoy meeting new people* ***50****. I find it very easy to play games with children that involve pretending.** ***(moved from imagination)***
Details/Patterns	**5.** I often notice small sounds when others do not. **6**. I usually notice car number plates or similar strings of information **9**. I am fascinated by dates. **12**. I tend to notice details that others do not. **19**. I am fascinated by numbers. **23**. I notice patterns in things all the time. **25**. It does not disturb me if my daily routine is disturbed* **43.** I like to plan any activities I participate in carefully.
Communication/ Mindreading	**7.** Other people frequently tell me that what I've said is impolite, even though I think it is polite. ***20****. When I am reading a story, I find it difficult to work out the characters' intentions.* ***(moved from imagination)*** **35.** I am often last to understand the point of a joke. ***37****. If there is an interruption, I can switch back to what I was doing very quickly.****(moved from attention switching)*** **39.** People often tell me that I keep going on and on about the same thing. **45**. I find it difficult to work out people's intentions.

*Asterisked items represent reverse scoring / Italicised items represent model modification.

Table 5. Description of the factor structure of the AQ as proposed by Hoekstra et al. (2008).

Factor	Items
Social Interaction:	**1.** I prefer to do things with others rather than on my own*
	11. I find social situations easy*
Social Skill	**13**. I would rather go to a library than a party.
	15. I tend to find myself drawn more strongly to people than to things*
	22. I find it hard to make new friends.
	36. I find it easy to work out what someone is thinking or feeling just by looking at their face.*
	44. I enjoy social occasions*
	45. I find it difficult to work out people's intentions
	47. I enjoy meeting new people*
	48. I am a good diplomat*
Attention Switching	**2**. I prefer to do things the same way over and over again
	4. I frequently get so strongly absorbed in one thing that I lose sight of other things
	10. In a social group, I can easily keep track of several different people's conversations*
	16. I tend to have very strong interests which I get upset about if I can't pursue.
	25. It does not disturb me if my daily routine is disturbed*
	32. I find it easy to do more than one thing at once*
	34. I enjoy doing things spontaneously*
	37. If there is an interruption, I can switch back to what I was doing very quickly.*
	43. I like to plan any activities I participate in carefully.
	46. New situations make me anxious
Communication	**7.** Other people frequently tell me that what I've said is impolite, even though I think it is polite
	17. I enjoy social chit-chat*
	18. When I talk, it isn't always easy for others to get a work in edgeways
	26. I frequently find that I don't know how to keep a conversation going
	27. I find it easy to 'read between the lines' when someone is talking to me*
	31. I know how to tell if someone listening to me is getting bored*
	33. When I talk on the phone, I'm not sure when it's my turn to speak
	35. I am often last to understand the point of a joke.
	38. I am good at social chit-chat*
	39. People often tell me that I keep going on and on about the same thing
Imagination	**3**.If I try to imagine something I find it very easy to create a picture in my mind*
	8. When I am reading a story, I can easily imagine what the characters might look like*

	14. I find making up stories easy* **20**. When I am reading a story, I find it difficult to work out the characters' intentions. **21.** I don't particularly enjoy reading fiction **24.** I would rather go to the theatre than a museum. **40.** When I was young, I used to enjoy playing games involving pretending with other children* **41**. I like to collect information about categories of things. **42**. I find it difficult to imagine what it would be like to be someone else **50**. I find it very easy to play games with children that involve pretending.*
Attention to Detail	**5**. I often notice small sounds when others do not **6**. I usually notice car number plates or similar strings of information **9**. I am fascinated by dates **12**. I tend to notice details that others do not. **19**. I am fascinated by numbers. **23**. I notice patterns in things all the time. **28**. I usually concentrate more on the whole picture rather than the small details* **29**. I am not very good at remembering phone numbers* **30**. I don't usually notice small changes in a situation or a person's appearance* **49**. I am not very good at remembering people's dates of birth*.

*Asterisked items represent reverse scoring.

Table 6: Description of the AQ structure as proposed by Stewart & Austin (2009).

Factor	Items
Socialness	**1.** I prefer to do things with others rather than on my own* **11**. I find social situations easy* **13**. I would rather go to a library than a party. **15**. I tend to find myself drawn more strongly to people than to things* ***17.*** *I enjoy social chit-chat**(**moved from communication)* ***18.*** *When I talk, it isn't always easy for others to get a work in edgeways**(moved from communication)*** **22**. I find it hard to make new friends. ***26.*** *I frequently find that I don't know how to keep a conversation going* ***(moved from communication)*** ***38.*** *I am good at social chit-chat**(**moved from communication)*** **44**. I enjoy social occasions* ***46****. New situations make me anxious* ***(moved from imagination)*** **47**. I enjoy meeting new people*
Patterns	**5.** I often notice small sounds when others do not **6**. I usually notice car number plates or similar strings of information **9**. I am fascinated by dates **12**. I tend to notice details that others do not. **19**. I am fascinated by numbers. **23**. I notice patterns in things all the time. **29.** I am not very good at remembering phone numbers* ***41****. I like to collect information about categories of things**(moved from imagination)***
Understanding Others/ Communication	***2****. I prefer to do things the same way over and over again* ***(moved from attention switching)*** **7.** Other people frequently tell me that what I've said is impolite, even though I think it is polite ***10****. In a social group, I can easily keep track of several different people's conversations***(moved from attention switching)*** ***20****. When I am reading a story, I find it difficult to work out the characters' intentions.* ***(moved from imagination)*** ***21.*** *I don't particularly enjoy reading fiction* ***(moved from imagination)*** **27.** I find it easy to 'read between the lines' when someone is talking to me* ***30.*** *I don't usually notice small changes in a situation or a person's appearance**(**moved from attention to detail)*** **31.** I know how to tell if someone listening to me is getting bored* ***32****. I find it easy to do more than one thing at once**(**moved from attention switching)*** **33.** When I talk on the phone, I'm not sure when it's my turn to speak **35.** I am often last to understand the point of a joke. ***36****. I find it easy to work out what someone is thinking or feeling just by looking at their face.** **(moved from social)***

	37*. If there is an interruption, I can switch back to what I was doing very quickly.* **(moved from attention switching)*** **39.** People often tell me that I keep going on and on about the same thing. ***45****. I find it difficult to work out people's intentions **(moved from social)*** ***48.*** *I am a good diplomat* **(moved from social)***
Imagination	**3**.If I try to imagine something I find it very easy to create a picture in my mind* ***4.*** *I frequently get so strongly absorbed in one thing that I lose sight of other things **(moved from attention switching)*** **8**. When I am reading a story, I can easily imagine what the characters might look like* **14**. I find making up stories easy* **40.** When I was young, I used to enjoy playing games involving pretending with other children* ***49.*** *I am not very good at remembering people's dates of birth* **(moved from attention to detail)*** **50**. I find it very easy to play games with children that involve pretending.*

Appendix 3: Ethical approval

Research Ethics Service: Fife

Research Ethics Service: Lothian

Caldicott Approval: Fife

Caldicott Approval: Lothian

NHS Fife NHS Forth Valley NHS Tayside

East of Scotland Tayside Research Ethics Service

Research Ethics Service Office
Residency Block
Level 2
Ninewells Hospital & Medical School
DUNDEE
DD1 9SY

RECEIVED
13 SEP 2010

Renata Kuenssberg
Specialist Psychological Practitioner
NHS Fife
Department of Psychology
Lynebank Hospital
Halbeath road
Dunfermline

Date: September 9th, 2010
Your Ref:
Our Ref: 10/GA/034
Enquiries to: Mrs Caroline Ackland
Extension: Ninewells extension 32589
Direct Line: 01382 632589
Email: caroline.ackland@nhs.net

Dear Renata,

Re: The association between the social-communication element of autism and repetitive interests, behaviours and activities: Factor analysis of the Adult Asperger Assessment

You have sought advice from the Research Ethics Office on the above project. The Research Ethics Co-ordinators and I have considered this and can advise that this does not require ethical review under the terms of the Governance Arrangement for Research Ethics Committees (GAfREC) in the UK. The advice is based on the following documentation provided to us:

Document	Version	Date
Protocol	Not specified	February 12th, 2010
Questionnaires AQ and EQ	Not specified	Not specified

- You are undertaking a factor analysis
- You are using anonymised routine clinical data
- You will require Caldicott Guardian approval

Please note that this advice is issued on behalf of the Research Ethics Service Office and does not constitute an opinion of a Research Ethics Committee (REC). It is intended to satisfy journal editors and conference organisers, who may require evidence of consideration of the need for ethical review prior to publication or presentation of your results.

You should keep a copy of this letter within your project file.

Yours sincerely,

Caroline

Caroline Ackland (Mrs)
Scientific Officer
East of Scotland Research Ethics Service

POSITIVE ABOUT DISABLED PEOPLE

South East Scotland Research Ethics Service

Deaconess House
148 Pleasance
Edinburgh
EH8 9RS
Tel: 0131 536 9067
Fax: 0131 536 9346

NHS Lothian

RECEIVED
19 APR 2010

Name: Renate Kuenssberg
Address: Trainee Clinical Psychologist
Lynebank Hospital
Halbeath Road
Dunfermline
KY11 4UW

Date: 13/04/2010
Your Ref:
Our Ref: NR/1004AB9
Enquiries to: Alex Bailey
Extension:
Direct Line: 0131 536 9050
Email: alex.bailey@nhslothian.scot.nhs.uk

Dear Renate,

Full title of project: The association between the social-communication element of autism and repetitive interests, behaviours and activities: Factor Analysis of the Adult Asperger Assessment

You have sought advice from the South East Scotland Research Ethics Service on the above project. This has been considered by the Scientific Officer and you are advised that, based on the submitted documentation (Thesis_Uni_ethics_form_-_abbreviated_120410[1]), it does not need NHS ethical review under the terms of the Governance Arrangements for Research Ethics Committees in the UK. The advice is based on the following:

- *The project is an audit using only data obtained as part of usual care, but note the requirement for Caldicott Guardian approval for the use or transfer of person-identifiable information within or from an organisation*

If this project is being conducted within NHS Lothian you should inform the relevant local Quality Improvement Team(s).

This letter should not be interpreted as giving a form of ethical approval or any endorsement of the project, but it may be provided to a journal or other body as evidence that ethical approval is not required under NHS research governance arrangements. However, if you, your sponsor/funder or any NHS organisation feels that the project should be managed as research and/or that ethical review by a NHS REC is essential, please write setting out your reasons and we will be pleased to consider further. Where NHS organisations have clarified that a project is not to be managed as research, the Research Governance Framework states that it should not be presented as research within the NHS.

You should retain a copy of this letter with your project file as evidence that you have sought advice from the South East Scotland Research Ethics Service.

Yours sincerely,

Alex Bailey
Scientific Officer
South East Scotland Research Ethics Service

Enclosure: NRES leaflet - "Defining Research"

NHS
Fife

APPLICATION FOR CALDICOTT APPROVAL FOR USE OF PATIENT IDENTIFIABLE DATA

User Details

Name: Renate Kuenssberg

Position: Specialist Psychological Practitioner

Organisation: NHS Fife

Address: Lynebank Hospital, Halbeath Road, Dunfermline

Postcode: KY11 4UW

Tel. No.: 01383 565 210

E-mail: renatekuenssberg@nhs.net

Name(s) of any co-user(s): Nil

You must address the 6 Caldicott Principles when submitting this request for data

1. Project title

The association between the social-communication element of autism and repetitive interests, behaviours and activities: Factor Analysis of the Adult Asperger Assessment.

2. Name of organisation receiving data (if not within NHS Fife)

N/A

3. What patient identifiable information are you looking to use? (please tick where relevant)

CHI Number	
Forename	Yes
Surname	Yes
Initials	
Age	Yes
Date of birth	
Gender	Yes
Address	

NHS
Fife

Postcode	
Other, please specify.....	Scores on the Autism quotient (AQ) and Empathy quotient (EQ), which make up the Adult Asperger Assessment (AAA) questionnaire used as standard in diagnosis of Aspergers.

4. Please explain how the proposal meets the following Six Caldicott Principles. (The Caldicott Committee Report on the Review of Patient-Identifiable Information. Department of Health, December 1997)

Justify the purpose

Principle 1 Justify the purpose(s)	Every proposed use or transfer of patient-identifiable information within or from an organisation should be clearly defined and scrutinised, with continuing uses regularly reviewed, by an appropriate guardian.

The primary purpose of using this data is to help inform and improve service provision for people with Aspergers syndrome by clarifying the diagnostic and assessment criteria.

Factor analysis of the Adult Asperger Assessment (AAA) will investigate whether the social elements of autism (social and communication deficits) covary with non-social elements (repetitive actions, interests and behaviours) within a high functioning population referred for assessment. This will help to inform understanding the construct of autism and clarify diagnostic and assessment criteria.

Justify the requirement to use patient-identifiable data

Principle 2 Don't use patient-identifiable information unless it is absolutely necessary	Patient-identifiable information items should not be included unless it is essential for the specified purpose(s) of that flow. The need for patients to be identified should be considered at each stage of satisfying the purpose(s).

A list of patients diagnosed with Aspergers using the AAA will be given to the user by case-holding clinicians. Each patient will be given a unique identifier number. The patient's age, gender and AAA scores will then be gathered from service-specific patient files. Clients cannot be identified from this information alone. Files of patients not diagnosed will not be accessed.

This AAA data will undergo exploratory factor analysis in order to understand to clarify the construct of Aspergers syndrome, as measured by this questionnaire.

Justify the inclusion of each data field required

V3 May 2010

Principle 3 Use the minimum necessary patient identifiable information	Where use of patient-identifiable information is considered to be essential, the inclusion of each individual item of information should be considered and justified so that the minimum amount of identifiable information is transferred or accessible as is necessary for a given function to be carried out.

Names of patients are required as a key to unique identifier numbers. This will ensure that the data can be traced back to client files if required. This information is not required for data analysis and will be kept separately and securely.

Age and gender of patients are required fields for univariate statistics, in order to allow the investigator to ensure there are no group differences (for instance between the sexes, or across different ages) in the construct of autism, and the diagnostic criteria being used.

Please outline arrangements for access to information

Principle 4 Access to patient-identifiable information should be on a strict need-to-know basis	Only those individuals who need access to patient-identifiable information should have access to it, and they should only have access to the information items that they need to see. This may mean introducing access controls or splitting information flows where one information flow is used for several purposes.

Patients who have been diagnosed with Aspergers syndrome can be identified by case holding clinicians. The user will only have access to these files to remove the AAA data and then work with an annonymised dataset. No one but the user will access patient-identifiable information.

As part of the research methodology other researchers (academic supervisors from the University of Edinburgh) may have temporary access to the anonymised data to give advice on statistical analysis and interpretation of the data.

Please outline action taken to ensure compliance with responsibilities and obligations to respect patient confidentiality

Principle 5 Everyone with access to patient-identifiable information should be aware of their responsibilities	Action should be taken to ensure that those handling patient-identifiable information - both clinical and non-clinical staff - are made fully aware of their responsibilities and obligations to respect patient confidentiality.

NHS
Fife

All personal information will be treated in line with NHS Fife policies regarding confidentiality and data protection, as well as the British Psychological Society Code of Conduct.

All data will be coded with unique identifiers. A complete key with patient identifiers will be stored at a separate location from the raw data, kept on paper only and kept within a locked filing cabinet within the NHS Fife Psychology Department. No personally identifiable information will be stored on computer. Access to identifiable data will be limited to the chief investigator.

Data gathering sheets with unique identifier, age, gender and AAA scores will be kept as paper records in a folder within a secure locker, within the NHS Fife Psychology department. An electronic database of this non-identifiable information will be made and kept on the secure NHS server. This data will be entered into a statistical package. All computers used will be password protected. Data storage will be in line with the Data Protection Act (1998) and NHS Fife policy.

The data will be held for a minimum period of 5 years in line with research guidelines and will be the responsibility of the chief investigator. All data will then be destroyed by paper shredding within confidential waste.

Please outline organisational compliance with legal requirements

Principle 6 Understand and comply with the law	Every use of patient-identifiable information must be lawful. Someone in each organisation handling patient information should be responsible for ensuring that the organisation complies with legal requirements.

All personal information will be treated in line with NHS Fife policies regarding confidentiality and data protection, as well as the British Psychological Society Code of Conduct. I am aware of my responsibility to comply with the requirements of the law and relevant guidelines relating to security and confidentiality of patient or other personal data.

5. Supporting information

As agreed: East Scotland Tayside Ethics form and thesis proposal from Edinburgh submitted separately

6. HAS YOUR APPLICATION BEEN TO RESEARCH ETHICS YES

If not, please explain why.

NHS
Fife

7. Who is the data custodian for the NHS data?

Name: KATHERINE CHESHIRE

Job Title: HEAD OF PSYCHOLOGY SERVICE NHS FIFE

Return Address: PSYCHOLOGY DEPARTMENT, LYNEBANK HOSPITAL

Email Address: kcheshire@nhs.net Personal Secretary: michellepatterson@nhs.n

Telephone Number: 01383 565421

Signature: ..... Date: 5.10.10

Counter-signature by Line Manager

Name: ALISON ROBERTSON

Job Title: HEAD OF LEARNING DISABILITY PSYCHOLOGY SERVICE

Signature: Alison Robertson Date: 29/9/10

Counter-signature by Operational Division/Primary Care Caldicott Guardian

Name: Stella A Clark

Job Title: Primary Care, Medical Director

Signature: Stella A Clark Date: 1.10.10

I authorise access to the data as noted above:

Signature: ..... Date: 6/11/10

DR EDWARD COYLE
Caldicott Guardian for NHS Fife

Lothian NHS Board

Public Health & Health Policy
Deaconess House
148 Pleasance
Edinburgh
EH8 9RS
Telephone 0131 536 9000
Fax 0131 536 9009
www.nhslothian.scot.nhs.uk

NHS Lothian

Ms Renate Kuenssberg
Trainee Clinical Psychologist
NHS Fife
Psychology Dept
Lynebank Hospital
Halbeath Road
Dunfermline KY11 4UW

Date 20 May 2010
Your Ref
Our Ref JS/MS/1076
Enquiries to Jim Sherval
Extension 89374
Direct Line 0131 536 9374
Direct Fax 0131 536 9164
Email Jim.Sherval@nhslothian.scot.nhs.uk

Dear Ms Kuenssberg,

Caldicott Application: The association between the social-communication element of autism and repetitive interests, behaviours and activities: Factor Analysis of the Adult Asperger Assessment

Thank you for the information supplied.

Request received from	Ms Renate Kuenssberg, Trainee Clinical Psychologist, NHS Fife
Summary of proposal	The primary aim of the project is to help inform and improve service provision within the Regional ASD Diagnostic Service for people with Aspergers syndrome by clarifying the diagnostic and assessment criteria. Factor analysis of the Adult Asperger Assessment (AAA) will investigate whether the social elements of autism (social and communication deficits) covary with non-social elements (repetitive actions, interests and behaviours) within a high functioning population referred for assessment to the Regional ASD Diagnostic service. This will add to the debate about understanding the construct of autism and clarify diagnostic and assessment criteria.
Patient identifiable information requested	Forename, Surname, Age, Gender, Other CHI
Approved	yes
Reason for decision	

Yours sincerely

Dr Alison McCallum
Director of Public Health & Health Policy

Appendix 4: CLASS: Evidence of Data Sharing Agreement

CLASS Information sharing agreement

1. Parties to the Agreement

This information sharing agreement is drawn up between:

Cambridge Lifespan Asperger Syndrome Service (CLASS)
Douglas House
18B Trumpington Road
Cambridge
CB2 8AH

Referred to as: the data owner

And:

Renate Kuenssberg
NHS Fife
Psychology Department
Lynebank Hospital
Halbeath Road
Dunfermline
KY11 4UW

Referred to as: the beneficiary

2. Period of Agreement

This agreement commences on *23rd November 2010* and will be subject to formal review on an annual basis. It will terminate or be extended prior to *23rd November 2013*.

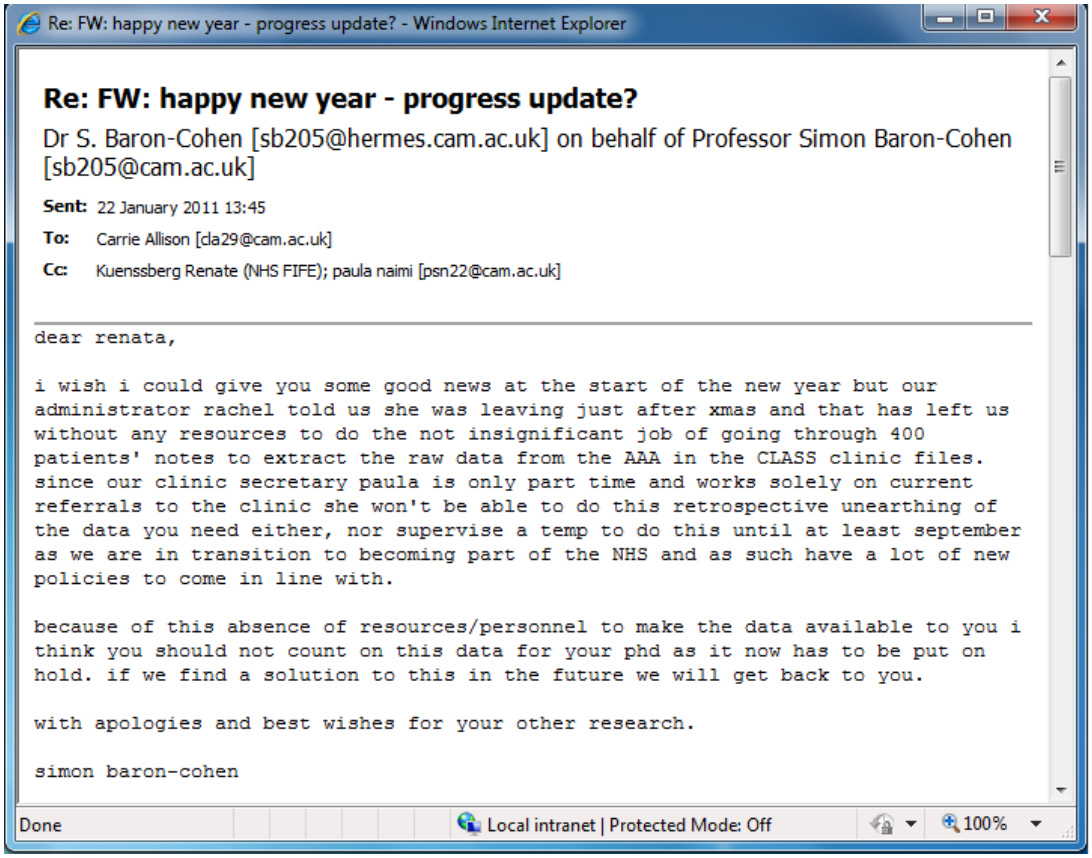
3. Data covered

Raw scores on the Autism quotient (AQ) and Empathy quotient (EQ) (which make up the Adult Asperger Assessment (AAA) questionnaire) of patients who have attended CLASS, along with the age and sex of patient. Clients cannot be identified from this information alone.

4. Permissions

All information will be treated in line with NHS Fife policies regarding confidentiality and data protection, as well as the British Psychological Society Code of Conduct. I am aware of my responsibility to comply with the requirements of the law and relevant guidelines relating to security and confidentiality of patient or other personal data.

The project has been approved by the University of Edinburgh Doctorate in Clinical Psychology ethics meeting. The panel consists of a number of lecturers and Clinical Psychologists at the University of


Re: FW: happy new year - progress update? - Windows Internet Explorer
Re: FW: happy new year - progress update?
Dr S. Baron-Cohen [sb205@hermes.cam.ac.uk] on behalf of Professor Simon Baron-Cohen [sb205@cam.ac.uk]
Sent: 22 January 2011 13:45
To: Carrie Allison [cla29@cam.ac.uk]
Cc: Kuenssberg Renate (NHS FIFE); paula naimi [psn22@cam.ac.uk]
dear renata,
i wish i could give you some good news at the start of the new year but our administrator rachel told us she was leaving just after xmas and that has left us without any resources to do the not insignificant job of going through 400 patients' notes to extract the raw data from the AAA in the CLASS clinic files. since our clinic secretary paula is only part time and works solely on current referrals to the clinic she won't be able to do this retrospective unearthing of the data you need either, nor supervise a temp to do this until at least september as we are in transition to becoming part of the NHS and as such have a lot of new policies to come in line with.
because of this absence of resources/personnel to make the data available to you i think you should not count on this data for your phd as it now has to be put on hold. if we find a solution to this in the future we will get back to you.
with apologies and best wishes for your other research.
simon baron-cohen
Done
Local intranet | Protected Mode: Off
100%

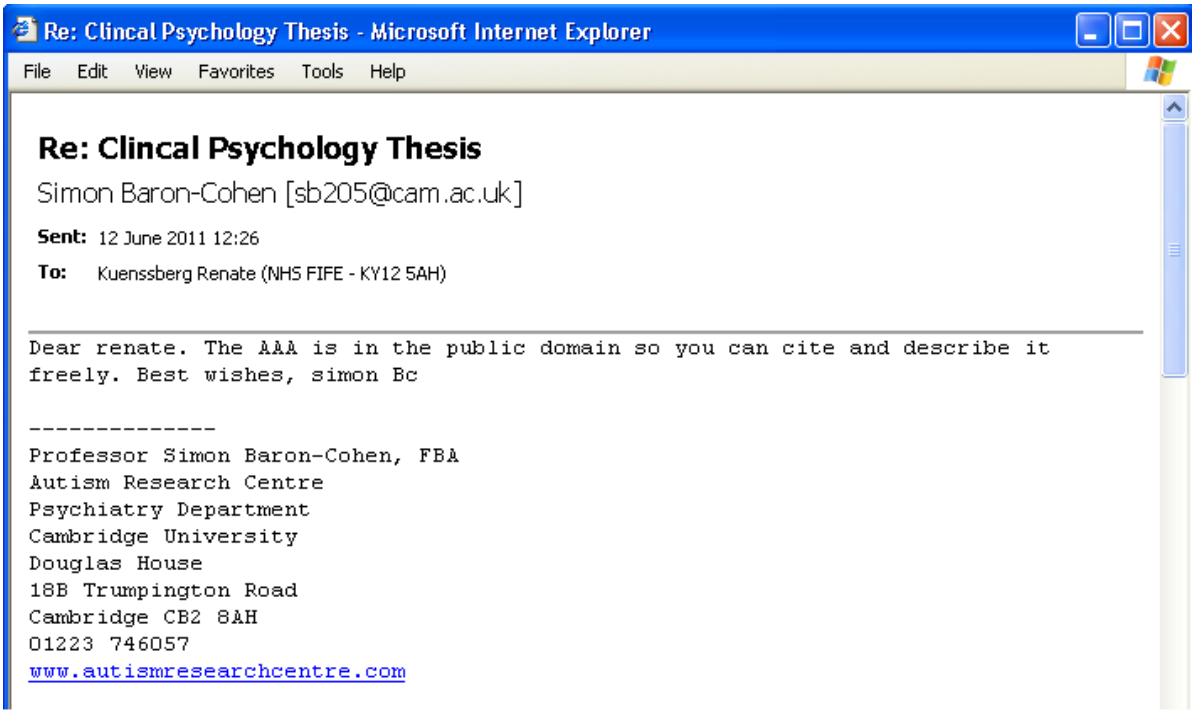
Appendix 5: Data Recording Sheet

Sex:	M	F
Age:		

ID

AQ									
1		11		21		31		41	
2		12		22		32		42	
3		13		23		33		43	
4		14		24		34		44	
5		15		25		35		45	
6		16		26		36		46	
7		17		27		37		47	
8		28		28		38		48	
9		19		29		39		49	
10		20		30		40		50	
EQ									
1		13		25		37		49	
2		14		26		38		50	
3		15		27		39		51	
4		16		28		40		52	
5		17		29		41		53	
6		18		30		42		54	
7		19		31		43		55	
8		20		32		44		56	
9		21		33		45		57	
10		22		34		46		58	
11		23		35		47		59	
12		24		36		48		60	

Appendix 6: Permission to describe AAA



Re: Clincal Psychology Thesis - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Re: Clincal Psychology Thesis

Simon Baron-Cohen [sb205@cam.ac.uk]

Sent: 12 June 2011 12:26

To: Kuenssberg Renate (NHS FIFE - KY12 5AH)

Dear renate. The AAA is in the public domain so you can cite and describe it freely. Best wishes, simon Bc

---

Professor Simon Baron-Cohen, FBA
Autism Research Centre
Psychiatry Department
Cambridge University
Douglas House
18B Trumpington Road
Cambridge CB2 8AH
01223 746057
www.autismresearchcentre.com

Appendix 7: Descriptive statistics for the AAA dataset.

Table 8. Descriptive Statistics of the AAA data

	N	Min.	Max.	Mean	Std. Dev.		N	Min.	Max.	Mean	Std. Dev.
A1	128	1	4	2.98	1.023	**A48**	127	1	4	3.08	1.059
A2	128	1	4	3.49	.774	**A50**	126	1	4	3.14	1.064
A4	127	1	4	3.74	.523	**B1**	127	1	4	2.95	1.007
A5	128	1	4	3.26	1.052	**B8**	128	1	4	3.57	.684
A6	128	1	4	2.86	1.169	**B10**	128	1	4	2.95	1.052
A7	127	1	4	2.81	1.167	**B11**	128	1	4	1.74	.966
A9	128	1	4	2.17	1.198	**B12**	128	1	4	2.85	1.020
A10	128	1	4	3.59	.736	**B14**	128	1	4	2.98	.951
A11	128	1	4	3.65	.716	**B15**	127	1	4	3.34	.866
A12	128	1	4	3.46	.752	**B19**	128	1	4	3.10	1.003
A14	128	1	4	2.69	1.234	**B21**	128	1	4	3.30	.854
A15	128	1	4	3.25	.869	**B22**	128	1	4	3.21	.902
A16	128	1	4	3.43	.781	**B25**	128	1	4	3.34	.798
A17	127	1	4	3.19	1.029	**B26**	128	1	4	2.91	1.031
A19	128	1	4	2.45	1.254	**B27**	128	1	4	2.48	1.079
A20	128	1	4	2.88	1.065	**B28**	128	1	4	2.79	1.025
A21	127	1	4	2.46	1.296	**B29**	127	1	4	3.28	.786
A22	128	1	4	3.66	.778	**B32**	128	1	4	2.23	1.076
A23	128	1	4	3.12	1.040	**B34**	128	1	4	3.23	.924
A24	127	1	4	2.96	1.130	**B35**	128	1	4	3.31	.929
A25	128	1	4	3.16	1.078	**B37**	127	1	4	2.98	.988
A26	128	1	4	3.57	.791	**B39**	128	1	4	2.86	1.033
A27	128	1	4	3.25	.905	**B41**	128	1	4	3.05	.933
A28	127	1	4	3.18	.963	**B43**	128	1	4	2.87	1.015
A30	128	1	4	2.73	1.112	**B44**	128	1	4	2.75	1.035
A31	128	1	4	2.84	1.083	**B46**	127	1	4	2.17	1.155

A33	128	1	4	2.94	1.078	**B48**	128	1	4	2.74	1.110
A35	128	1	4	2.87	1.053	**B49**	125	1	4	2.64	1.035
A36	128	1	4	3.26	.958	**B50**	127	1	4	2.51	1.140
A38	128	1	4	3.44	.894	**B52**	128	1	4	3.30	.769
A39	127	1	4	3.28	.959	**B54**	128	1	4	3.49	.710
A40	127	1	4	2.81	1.187	**B55**	128	1	4	3.27	.900
A41	128	1	4	3.00	1.184	**B57**	127	1	4	2.65	1.218
A42	127	1	4	3.28	.933	**B58**	127	1	4	3.16	.868
A44	128	1	4	3.13	.991	**B59**	126	1	4	2.94	1.061
A45	127	1	4	3.38	.881	**B60**	126	1	4	2.31	.975

Appendix 8: Skewness and Kurtosis z scores for the AAA.

Table 10. Skewness and Kurtosis z scores for AAA items

AQ Items	*Z skewness*	*Z kurtosis*	**EQ Items**	*Z skewness*	*Z kurtosis*
AQ1	**-2.92**	-1.82	EQ1	**-2.42**	**-2.08**
AQ2	**-7.60**	**5.52**	EQ8	**-7.52**	**5.42**
AQ4	**-10.5**	**14.46**	EQ10	**-2.76**	**-2.10**
AQ5	-0.58	0.42	EQ11	**4.76**	-0.41
AQ5	**-2.49**	**-2.86**	EQ12	**-2.17**	**-2.12**
AQ7	-1.80	**-3.18**	EQ14	**-3.17**	-0.97
AQ9	**2.21**	**-3.15**	EQ15	**-5.08**	0.48
AQ10	**-9.12**	**8.09**	EQ19	**-3.64**	-1.37
AQ11	**-10.4**	**10.9**	EQ21	**-5.39**	1.69
AQ12	**-6.76**	**4.40**	EQ22	**-4.15**	0.36
AQ14	-0.93	**-3.74**	EQ25	**-4.60**	0.38
AQ15	**-4.78**	0.77	EQ26	-1.36	**-2.99**
AQ16	**-6.20**	**2.95**	EQ27	-0.52	**-2.98**
AQ17	**-4.28**	-1.08	EQ28	1.72	**-2.34**
AQ19	0.05	**-3.88**	EQ29	**-4.41**	1.11
AQ20	**-2.15**	**-2.49**	EQ32	0.99	**-3.02**
AQ21	0.37	**-4.02**	EQ34	**-4.75**	0.23
AQ22	**-10.6**	**9.74**	EQ35	**-5.91**	1.52
AQ23	**-4.5**	0.61	EQ37	**-3.05**	-1.40
AQ24	**-2.76**	**-2.61**	EQ39	**-2.32**	**-2.12**
AQ25	**-4.78**	-0.73	EQ41	**-3.55**	-0.63
AQ26	**-8.82**	**6.62**	EQ43	-1.95	**-2.28**
AQ27	**-3.93**	-1.13	EQ44	-0.81	**-2.82**
AQ28	**-4.50**	-0.22	EQ46	1.75	**-3.17**
AQ30	-1.70	**-2.85**	EQ48	-1.64	**-2.88**
AQ31	-1.52	**-2.96**	EQ49	-0.74	**-2.61**
AQ33	**-2.99**	**-2.05**	EQ50	-0.14	**-3.29**
AQ35	-2.20	**-2.36**	EQ52	0.96	-1.46
AQ36	**-4.56**	-0.66	EQ54	**-5.51**	1.28
AQ38	**-7.11**	**3.06**	EQ55	**-3.81**	-1.47
AQ39	**-5.59**	0.89	EQ57	-0.8	**-3.65**
AQ40	-1.89	**-3.23**	EQ58	**-2.83**	-1.59
AQ41	**-3.24**	**-2.69**	EQ59	**-2.70**	**-2.16**
AQ42	**-5.27**	0.60	EQ60	1.82	-1.85

AQ44	**-3.80**	-1.22			
AQ45	**-6.46**	**2.62**			
AQ48	**-3.40**	-1.94			
AQ50	**-3.60**	**-2.03**			

*Values in bold indicate those distributions which may depart from normality.

Appendix 9: AAA: Standardised Factor Loadings and Residual Variance.

Table 12. Model AAA1: Standardised Factor Loadings and Residual Variance.

Item	Loading on …				Residual Variance
	Social	RIBA	Comm	Imag	
AQ1	0.342				0.883
AQ10	0.438				0.808
AQ11	0.530				0.719
AQ15	0.524				0.725
AQ20	0.466				0.783
AQ22	0.469				0.780
AQ27	0.577				0.668
AQ35	0.545				0.703
AQ36	0.591				0.651
AQ44	0.528				0.721
AQ45	0.626				0.608
EQ8	0.592				0.649
EQ11	-0.043				0.998
EQ12	0.467				0.782
EQ19	0.572				0.672
EQ21	0.481				0.768
EQ22	0.566				0.680
EQ25	0.719				0.484
EQ26	0.634				0.598
EQ32	0.235				0.945
EQ35	0.402				0.838
EQ39	0.026				0.999
EQ43	0.375				0.860
EQ44	0.589				0.654
EQ48	0.441				0.806
EQ49	0.547				0.700
EQ50	0.364				0.868
EQ52	0.770				0.499

EQ55	0.586				0.657
EQ57	0.045				0.998
EQ58	0.606				0.633
EQ59	0.484				0.766
AQ2		0.503			0.747
AQ4		0.392			0.846
AQ5		0.358			0.872
AQ6		0.535			0.714
AQ 9		0.451			0.797
AQ12		0.501			0.749
AQ16		0.423			0.821
AQ19		0.592			0.650
AQ23		0.728			0.471
AQ25		0.358			0.872
AQ28		0.477			0.772
AQ30		0.097			0.991
AQ41		0.313			0.902
EQ10		0.130			0.983
EQ60		-0.001			1.000
AQ7			0.492		0.758
AQ17			0.563		0.683
AQ26			0.439		0.807
AQ31			0.365		0.867
AQ33			0.558		0.688
AQ38			0.619		0.617
AQ39			0.370		0.863
AQ48			0.496		0.754
EQ1			0.691		0.522
EQ14			0.585		0.657
EQ15			0.424		0.820
EQ27			0.383		0.853
EQ28			0.413		0.829

EQ29			0.401		0.839
EQ34			0.349		0.878
EQ37			0.239		0.943
EQ41			0.615		0.621
EQ46			0.177		0.969
EQ54			0.708		0.499
AQ14				0.304	0.883
AQ21				0.342	0.883
AQ24				0.391	0.847
AQ40				0.625	0.609
AQ42				0.624	0.611
AQ50				0.647	0.582

Table 13. Model AAA2: Standardised Factor Loadings and Residual Variance.

Items	Loading on…			Residual Variance
	Social	RIBA/ Imag	Comm	
AQ1	0.345			0.881
AQ10	0.432			0.814
AQ11	0.529			0.721
AQ15	0.518			0.731
AQ20	0.459			0.789
AQ22	0.475			0.775
AQ27	0.581			0.662
AQ35	0.541			0.683
AQ36	0.591			0.650
AQ44	0.520			0.730
AQ45	0.621			0.730
EQ8	0.600			0.640
EQ11	-0.041			0.998
EQ12	0.464			0.785
EQ19	0.574			0.670
EQ21	0.479			0.770
EQ22	0.560			0.687
EQ25	0.720			0.482
EQ26	0.640			0.590
EQ32	0.228			0.948
EQ35	0.407			0.834
EQ39	0.030			0.999
EQ43	0.371			0.862
EQ44	0.596			0.645
EQ48	0.448			0.799
EQ49	0.550			0.697
EQ50	0.348			0.879
EQ52	0.779			0.394

EQ55	0.591			0.651
EQ57	0.053			0.997
EQ58	0.601			0.638
EQ59	0.471			0.958
AQ2		0.553		0.694
AQ4		0.398		0.841
AQ5		0.312		0.903
AQ6		0.442		0.805
AQ9		0.402		0.839
AQ12		0.395		0.844
AQ16		0.406		0.835
AQ19		0.447		0.800
AQ23		0.567		0.678
AQ25		0.381		0.855
AQ28		0.527		0.662
AQ30		0.104		0.989
AQ41		0.401		0.839
EQ10		0.193		0.963
EQ60		0.206		0.958
AQ14		-0.064		0.996
AQ21		0.254		0.935
AQ24		0.335		0.888
AQ40		0.370		0.863
AQ42		.0382		0.854
AQ50		0.240		0.942
AQ7			0.503	0.747
AQ17			0.556	0.690
AQ26			0.433	0.813
AQ31			0.362	0.869
AQ33			0.563	0.683
AQ38			0.609	0.629
AQ39			0.385	0.852

AQ48			0.494	0.756
EQ1			0.689	0.525
EQ14			0.592	0.650
EQ15			0.428	0.816
EQ27			0.393	0.846
EQ28			0.419	0.825
EQ29			0.409	0.833
EQ34			0.363	0.868
EQ37			0.241	0.942
EQ41			0.614	0.623
EQ46			0.186	0.965
EQ54			0.700	0.510

Table 14. Model AAA3: Standardised Factor Loadings and Residual Variance.

Items	Loading on…			Residual Variance
	Social	RIBA	Comm / Imag	
AQ1	0.344			0.882
AQ10	0.437			0.809
AQ11	0.530			0.719
AQ15	0.528			0.721
AQ20	0.467			0.781
AQ22	0.471			0.778
AQ27	0.575			0.670
AQ35	0.546			0.701
AQ36	0.590			0.652
AQ44	0.531			0.718
AQ45	0.628			0.606
EQ8	0.594			0.648
EQ11	-0.044			0.998
EQ12	0.471			0.778
EQ19	0.571			0.674
EQ21	0.481			0.769
EQ22	0.568			0.677
EQ25	0.719			0.482
EQ26	0.631			0.602
EQ32	0.237			0.944
EQ35	0.401			0.839
EQ39	0.025			0.999
EQ43	0.375			0.859
EQ44	0.585			0.657
EQ48	0.440			0.806
EQ49	0.546			0.702
EQ50	0.369			0.864
EQ52	0.766			0.413

EQ55	0.583			0.660
EQ57	0.044			0.998
EQ58	0.605			0.634
EQ59	0.487			0.763
AQ2		0.497		0.753
AQ4		0.376		0.859
AQ5		0.368		0.864
AQ6		0.537		0.712
AQ 9		0.454		0.794
AQ12		0.508		0.742
AQ16		0.407		0.834
AQ19		0.595		0.646
AQ23		0.742		0.449
AQ25		0.249		0.878
AQ28		0.473		0.777
AQ30		0098		0.990
AQ41		0.317		0.900
EQ10		0.109		0.988
EQ60		-0.008		1.000
AQ7			0.483	0.766
AQ17			0.574	0.671
AQ26			0.442	0.805
AQ31			0.357	0.873
AQ33			0.501	0.687
AQ38			0.627	0.607
AQ39			0.357	0.872
AQ48			0.501	0.749
EQ1			0.695	0.516
EQ14			0.568	0.678
EQ15			0.417	0.826
EQ27			0.381	0.854
EQ28			0.407	0.824

EQ29			0.397	0.842
EQ34			0.337	0.887
EQ37			0.241	0.942
EQ41			0.612	0.625
EQ46			0.169	0.972
EQ54			0.711	0.495
AQ14			0.071	0.995
AQ21			0.217	0.953
AQ24			0.418	0.825
AQ40			0.440	0.806
AQ42			0.533	0.716
AQ50			0.428	0.817

Table 15. Model AAA4: Standardised Factor Loadings and Residual Variance.

Items	Loading on…			Residual Variance
	Social/ Imag	RIBA	Comm	
AQ1	0.341			0.884
AQ10	0.436			0.810
AQ11	0.529			0.720
AQ15	0.529			0.720
AQ20	0.471			0.778
AQ22	0.469			0.780
AQ27	0.570			0.675
AQ35	0.550			0.698
AQ36	0.587			0.656
AQ44	0.535			0.714
AQ45	0.631			0.602
EQ8	0.590			0.652
EQ11	-0.042			0.998
EQ12	0.476			0.774
EQ19	0.570			0.675
EQ21	0.484			0.766
EQ22	0.571			0.674
EQ25	0.716			0.488
EQ26	0.626			0.608
EQ32	0.243			0.941
EQ35	0.400			0.840
EQ39	0.025			0.999
EQ43	0.374			0.860
EQ44	0.580			0.663
EQ48	0.442			0.804
EQ49	0.544			0.704
EQ50	0.380			0.856
EQ52	0.759			0.425

EQ55	0.577			0.667
EQ57	0.041			0.998
EQ58	0.602			0.637
EQ59	0.492			0.758
AQ14	0.109			0.988
AQ21	0.209			0.956
AQ24	0.415			0.828
AQ40	0.434			0.812
AQ42	0.527			0.722
AQ50	0.439			0.807
AQ2		0.503		0.747
AQ4		0.394		0.844
AQ5		0.356		0.873
AQ6		0.535		0.714
AQ 9		0.451		0.797
AQ12		0.499		0.751
AQ16		0.425		0.819
AQ19		0.592		0.650
AQ23		0.726		0.473
AQ25		0.360		0.870
AQ28		0.479		0.771
AQ30		0.096		0.991
AQ41		0.312		0.902
EQ10		0.133		0.982
EQ60		0.000		1.000
AQ7			0.494	0.756
AQ17			0.567	0.678
AQ26			0.442	0.805
AQ31			0.360	0.870
AQ33			0.562	0.684
AQ38			0.621	0.615
AQ39			0.369	0.864

AQ48			0.495	0.755
EQ1			0.691	0.522
EQ14			0.581	0.662
EQ15			0.424	0.821
EQ27			0.388	0.850
EQ28			0.415	0.827
EQ29			0.402	0.838
EQ34			0.348	0.879
EQ37			0.239	0.943
EQ41			0.612	0.626
EQ46			0.177	0.969
EQ54			0.705	0.503

Table 16. Model AAA6: Standardised Factor Loadings and Residual Variance

Items	**Loading on…**		**Residual Variance**
	Comm / Soc	RIBA/ Imag	
AQ1	0.344		0.882
AQ10	0.427		0.818
AQ11	0.532		0.717
AQ15	0.514		0.735
AQ20	0.457		0.792
AQ22	0.469		0.780
AQ27	0.572		0.673
AQ35	0.538		0.710
AQ36	0.583		0.660
AQ44	0.532		0.717
AQ45	0.622		0.613
EQ8	0.601		0.639
EQ11	-0.039		0.998
EQ12	0.478		0.772
EQ19	0.572		0.673
EQ21	0.491		0.759
EQ22	0.561		0.685
EQ25	0.703		0.506
EQ26	0.628		0.605
EQ32	0.246		0.939
EQ35	0.416		0.827
EQ39	0.025		0.999
EQ43	0.359		0.871
EQ44	0.584		0.659
EQ48	0.465		0.783
EQ49	0.547		0.700
EQ50	0.362		0.869
EQ52	0.768		0.410

EQ55	0.567		0.678
EQ57	0.069		0.995
EQ58	0.586		0.656
EQ59	0.469		0.780
AQ7	0.448		0.799
AQ17	0.568		0.678
AQ26	0.431		0.814
AQ31	0.355		0.874
AQ33	0.523		0.727
AQ38	0.634		0.598
AQ39	0.344		0.881
AQ48	0.521		0.728
EQ1	0.699		0.512
EQ14	0.554		0.693
EQ15	0.417		0.826
EQ27	0.344		0.882
EQ28	0.369		0.864
EQ29	03376		0.859
EQ34	0.311		0.903
EQ37	0.236		0.944
EQ41	0.621		0.614
EQ46	0.146		0.979
EQ54	0.729		0.469
AQ2		0.533	0.716
AQ4		0.385	0.852
AQ5		0.306	0.905
AQ6		0.425	0.820
AQ9		0.409	0.833
AQ12		0.365	0.867
AQ16		0.379	0.856
AQ19		0.433	0.812
AQ23		0.566	0.679

AQ25		0.391	0.847
AQ28		0.537	0.711
AQ30		0.091	0.992
AQ41		0.405	0.836
EQ10		0.149	0.978
EQ60		0.231	0.947
AQ14		-0.024	0.999
AQ21		0.280	0.922
AQ24		0.347	0.879
AQ40		0.405	0.836
AQ42		0.396	0.843
AQ50		0.264	0.930

Table 17. Model AAA7: Standardised Factor Loadings and Residual Variance

Items	Loading on…		Residual Variance
	Comm / Soc / Imag	RIBA/	
AQ1	0.342		0.883
AQ10	0.431		0.814
AQ11	0.533		0.716
AQ15	0.524		0.725
AQ20	0.579		0.783
AQ22	0.467		0.782
AQ27	0.566		0.680
AQ35	0.543		0.705
AQ36	0.584		0.659
AQ44	0.541		0.707
AQ45	0.629		0.604
EQ8	0.596		0.645
EQ11	-0.042		0.998
EQ12	0.484		0.766
EQ19	0.568		0.677
EQ21	0.490		0.759
EQ22	0.569		0.677
EQ25	0.705		0.503
EQ26	0.620		0.616
EQ32	0.253		0.936
EQ35	0.408		0.833
EQ39	0.020		1.000
EQ43	0.363		0.868
EQ44	0.573		0.672
EQ48	0.454		0.794
EQ49	0.541		0.707
EQ50	0.383		0.853

EQ52	0.756		0.428
EQ55	0.563		0.683
EQ57	0.059		0.997
EQ58	0.591		0.651
EQ59	0.485		0.764
AQ7	0.440		0.807
AQ17	0.579		0.665
AQ26	0.436		0.810
AQ31	0.347		0.879
AQ33	0.526		0.723
AQ38	0.642		0.588
AQ39	0.329		0.892
AQ48	0.525		0.724
EQ1	0.699		0.511
EQ14	0.535		0.714
EQ15	0.409		0.833
EQ27	0.342		0.883
EQ28	0.364		0.867
EQ29	0.372		0.861
EQ34	0.298		0.911
EQ37	0.236		0.944
EQ41	0.615		0.622
EQ46	0.137		0.981
EQ54	0.731		0.466
AQ14	0.097		0.991
AQ21	0.208		0.957
AQ24	0.416		0.827
AQ40	0.436		0.810
AQ42	0.526		0.723
AQ50	0.435		0.811
AQ2		0.474	0.775
AQ4		0.373	0.861

AQ5		0.366	0.866
AQ6		0.537	0.712
AQ9		0.462	0.787
AQ12		0.496	0.754
AQ16		0.393	0.846
AQ19		0.605	0.634
AQ23		0.762	0.419
AQ25		0.357	0.873
AQ28		0.475	0.775
AQ30		0.085	0.993
AQ41		0.307	0.906
EQ10		0.087	0.992
EQ60		-0.011	1.000